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## THE CALIBRATION OF PHOTOGRAPHIC AND SPECTROSCOPIC FILMS

- I. Film Batch Variations of Reciprocity Failure in IIAO film
- II. Thermal and Aging Effects in Relationship to Reciprocity Failure
- III. Shifting of Reciprocity Failure Points as a Function of Thermal and Aging Effects

{NASA-CR-181334} THE CALIBRATION OF  
PHOTOGRAPHIC AND SPECTROSCOPIC FILMS. PART  
1: FILM BATCH VARIATIONS OF RECIPROCITY  
FAILURE IN IIAO FILM. PART 2: THERMAL AND  
AGING EFFECTS IN (Morgan State Univ.) 51 p

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### SEMI-ANNUAL REPORT

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BY

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## ABSTRACT

Reciprocity failure was examined for 11aO spectroscopic film. Three separate experiments were performed in order to study film batch variations, thermal and aging effects in relationship to reciprocity failure, and shifting of reciprocity failure points as a function of thermal and aging effects. The failure was examined over ranges of time between 5 and 60 seconds. The variation to illuminance was obtained by using thirty neutral density filters. A standard sensitometer device imprinted the wedge pattern on the film as exposure time was subjected to variation. Our results indicate that film batch differences, temperature and aging play an important role in reciprocity failure of 11aO spectroscopic film. A shifting of the failure points was also observed in various batches of film.

## INTRODUCTION

An examination of reciprocity failure using IlaO film is necessary because of the utilization of that medium for experiments performed when NASA's Ultraviolet Imaging Telescope, (UIT), is in orbit, and including other ultraviolet experiments that may be conducted by the University of Wisconsin and others. Three separate experiments were performed in order to examine reciprocity failure. They were:

- (A) Film Batch Variations of Reciprocity Failure in IlaO film
- (B) Thermal and Aging Effects in Relationship to Reciprocity Failure
- (C) Shifting of Reciprocity Failure Points as a Function of Thermal and Aging Effects.

## MATERIALS AND METHODS

The standardized wedge patterns were placed on IlaO Spectroscopic film in total darkness using a sensitometer with a 24 hour burn in time for the bulb. Each film section was exposed to the light source for a specific period of time. Time exposures were in intervals of 5 seconds from 5 - 60 seconds.

The development process included 4 minutes in Kodak D-19 developer, 4 minutes in Kodak rapid fixer, followed by three minutes in Hypo Clearing Agent and one minute in Photo Flo. The film was washed for 30 seconds between developer and fixer. After the fixer process, the film was washed and the anti-reflection coating was removed with a soft sponge. The agitation of the film, in the developer and fixer, included a 30 second agitation followed by a 30 second soak, then a 10 second agitation - 20 second soak sequence up to 4 minutes. All chemicals were in a water bath at a standard temperature of 20°C.

Next, the film was dried for a period of approximately 24 hours, and the optical densities were read using a MacBeth Densitometer. The density readings were then recorded and graphed. The graph coordinates were optical density vs. exposure time.

#### (A) Film Batch Variations of Reciprocity Failure in 11a0 film

Four different film samples were used in order to study reciprocity failure in 11a0 film. These four samples of film were exposed for various time periods in order to detect reciprocity failure. Earlier experiments have shown that reciprocity failure in 11a0 film can occur around 30 seconds of light exposure. The four film samples were initially exposed to light from a sensitometer for periods of 10, 15, 20, 25, 27, 30, 33, 35 and 40 seconds. In order to verify that reciprocity failure occurs at 30 seconds, a second experiment was designed to focus on exposure times of approximately 30 seconds. For this study, exposure times of 25, 27, 30, 33, 35 and 38 seconds were chosen.

Each film sample was developed and the densities were measured by a MacBeth Densitometer. The densities were then graphed by an IBM personal computer. The film samples were number coded for proper identification. The numbered samples are as follows:

- 1 - aged film sample 0608-004-111 (-/-)
- 2 - new film sample 0608-003-111 ( $\Delta$ )
- 3 - Ernie film sample 5bc0608-007 ( $\diamond$ )
- 4 - aged film sample d0608-007-111 ( $\odot$ )

Each individual wedge for each film sample was graphed as a function of optical density vs. exposure time.

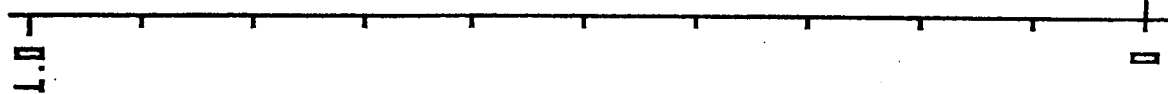
#### RESULTS

The results seem to indicate that there was minimal reciprocity failure of all samples at the lighter density wedges ranging from wedge 1 to wedge 6. (see graphs 1 - 6). However, as the densities increased, each film sample began to show reciprocity failure at different exposure times. This phenomena is illustrated in graphs 7 - 30. The results also indicate that there is a shifting of the failure points which could be due to thermal, aging and batch differences between various film samples. It should be noted that this experiment included four different batches of film. The results clearly indicate that batch to batch variations play a substantial role in the phenomenon reciprocity failure.

RECIPROCITY FAILURE

WEDGE 1 (8/7/85)

OPTICAL DENSITY



5

10

15

20

25

30

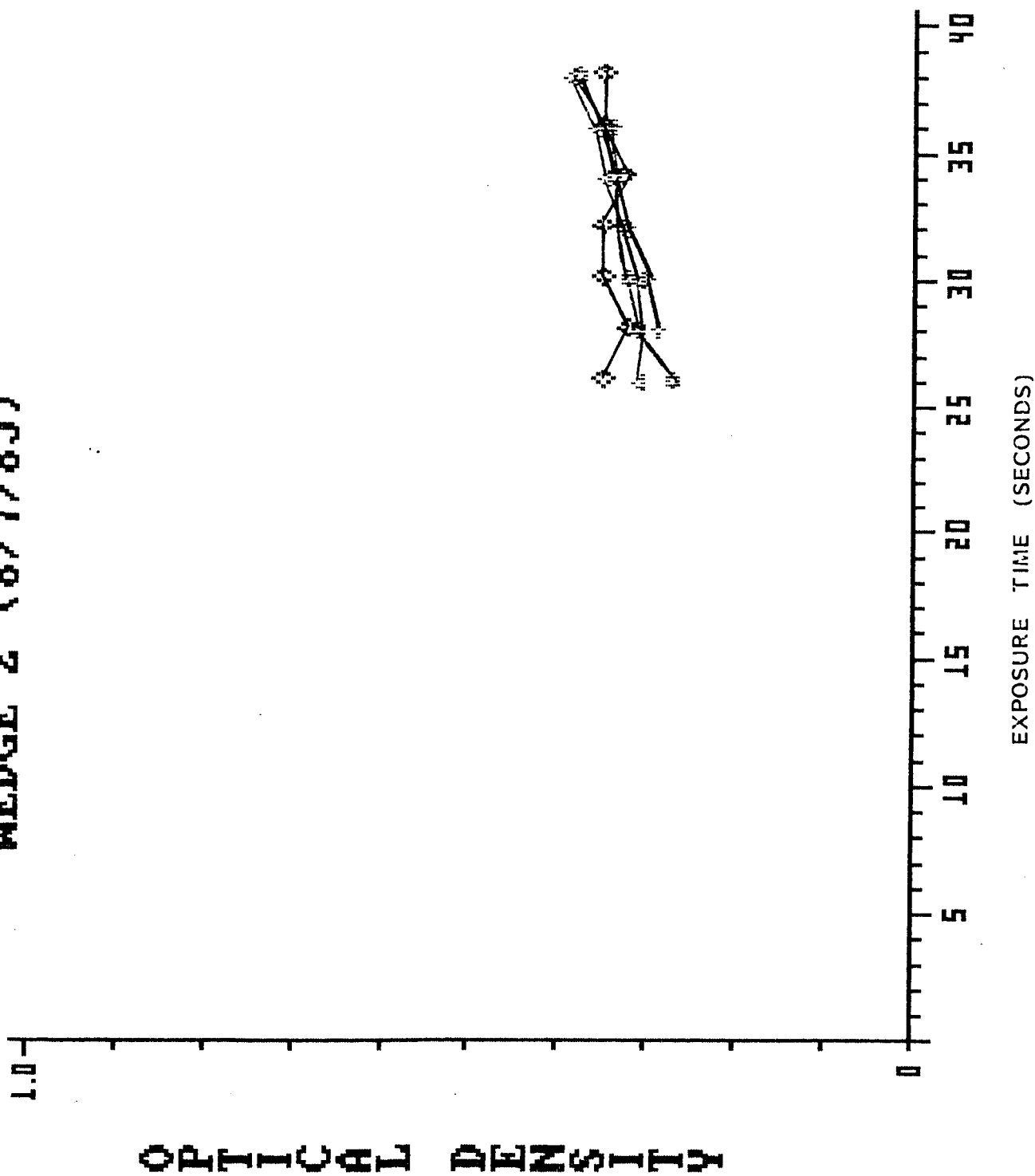
35

40

EXPOSURE TIME (SECONDS)

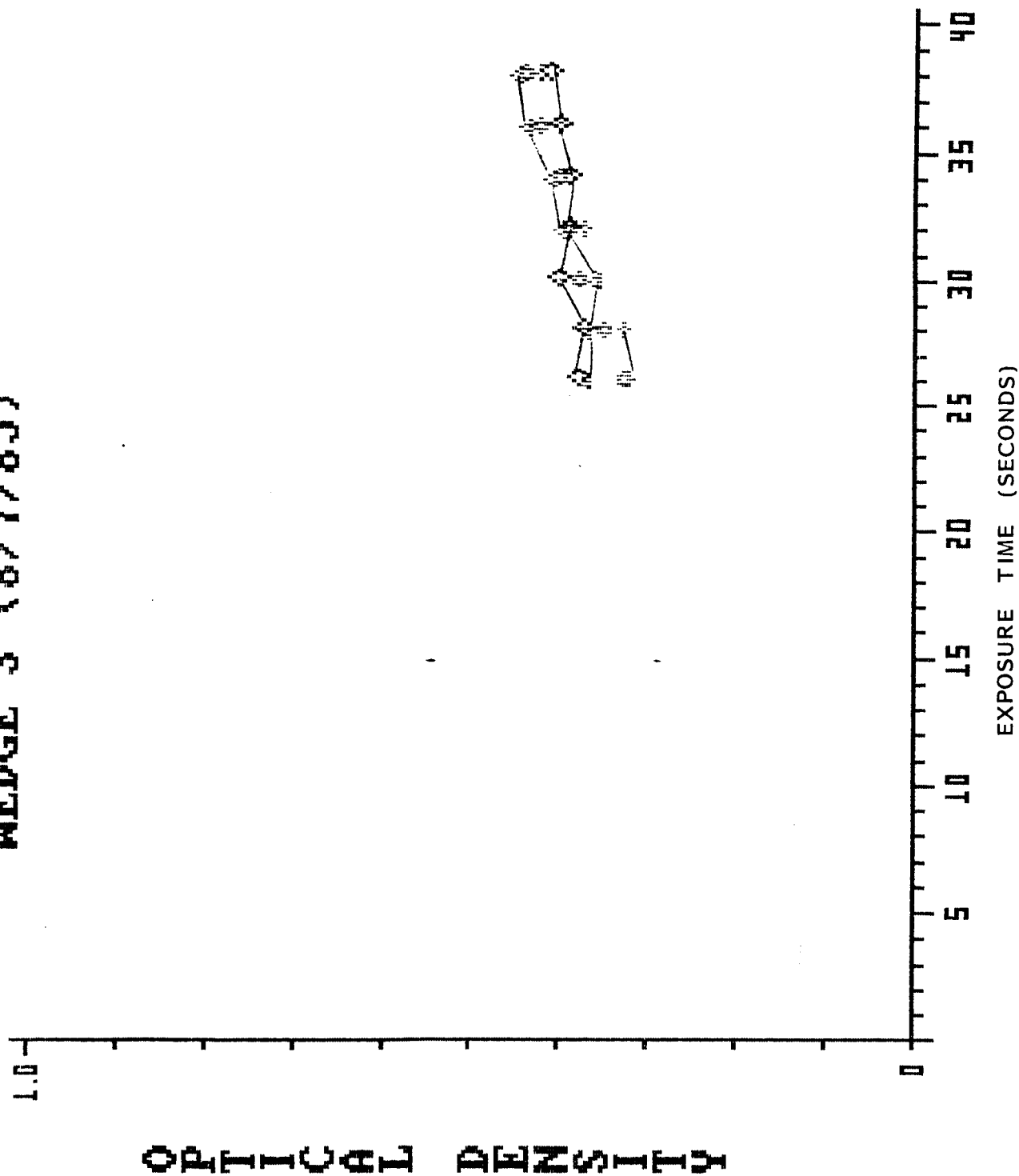
RECIPROCITY FAILURE

WEDGE 2 (8/7/85)



RECIPROCITY FAILURE

WEDGE 3 (8/7/85)

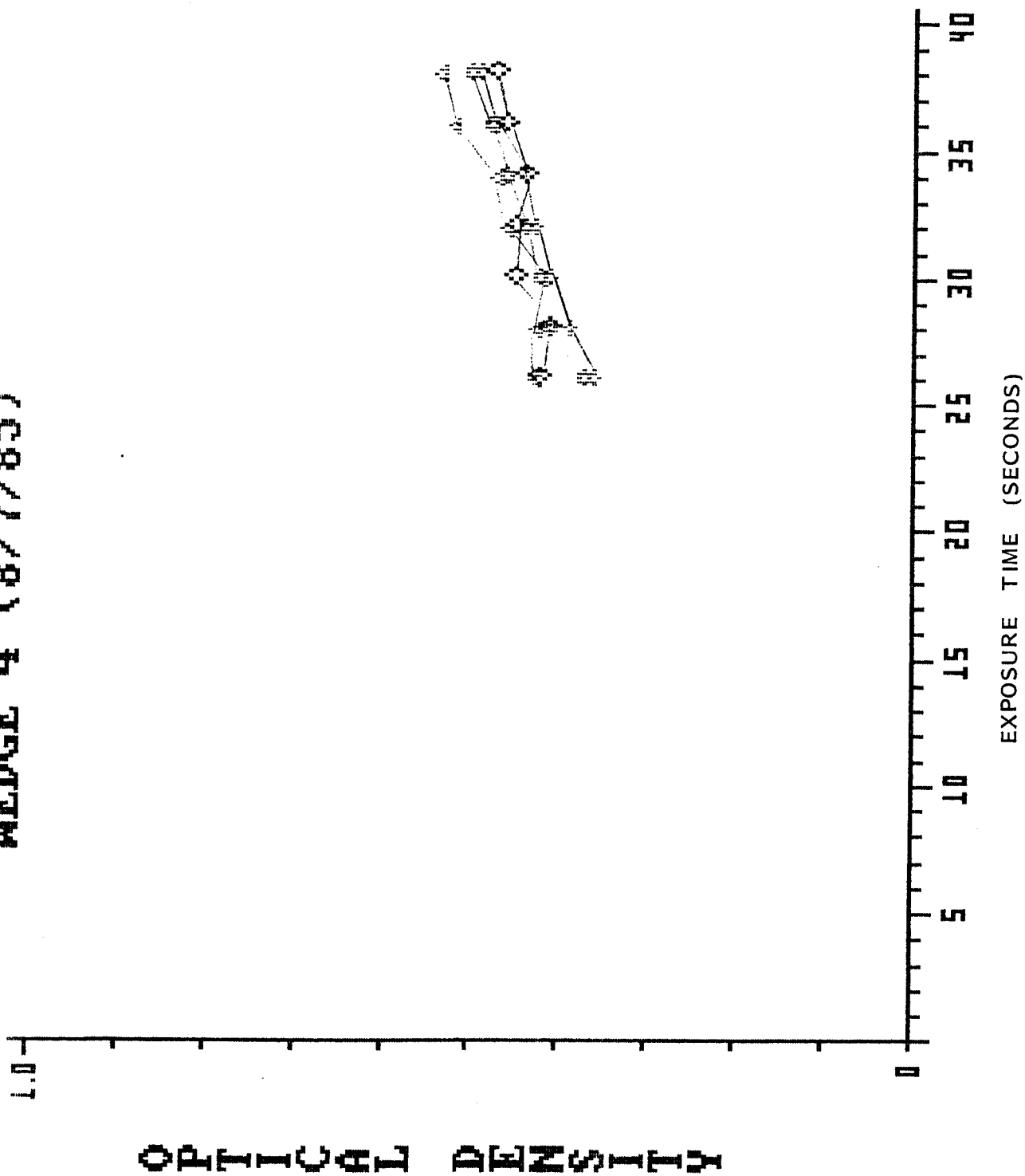






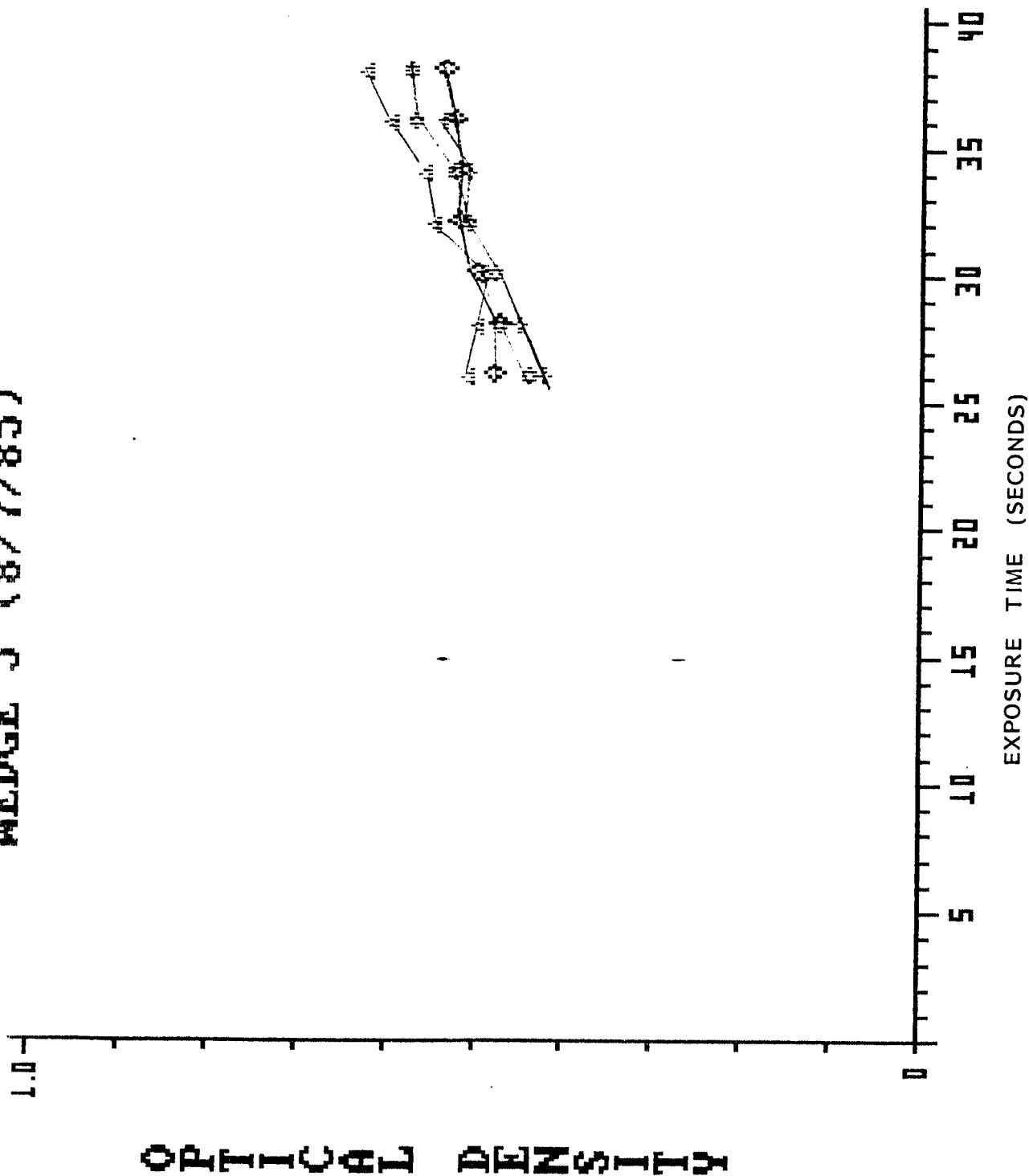
RECIPROCITY FAILURE

WEDGE 4 (8/7/85)

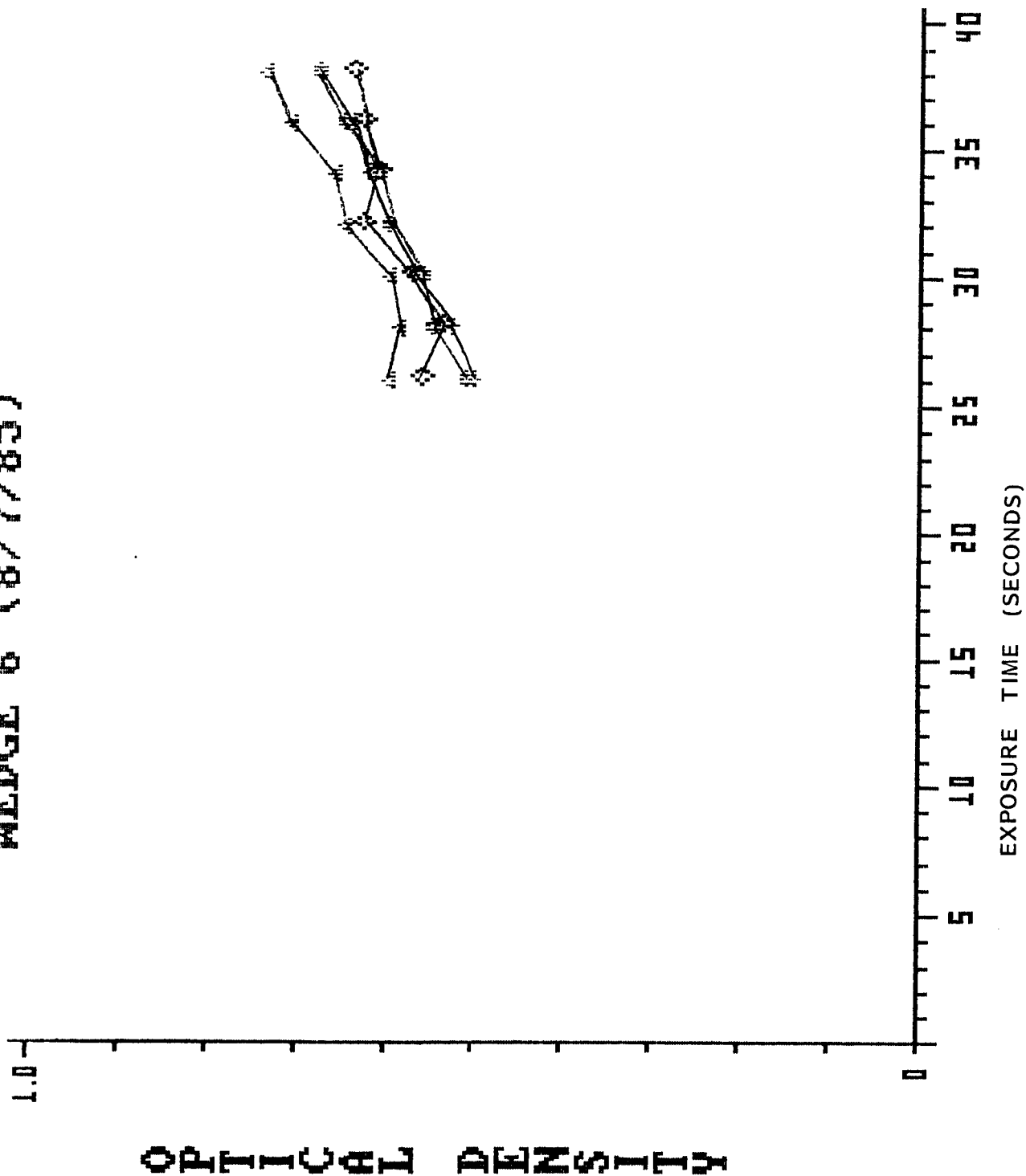


RECIPROCITY FAILURE

WEDGE 5 (8/7/85)

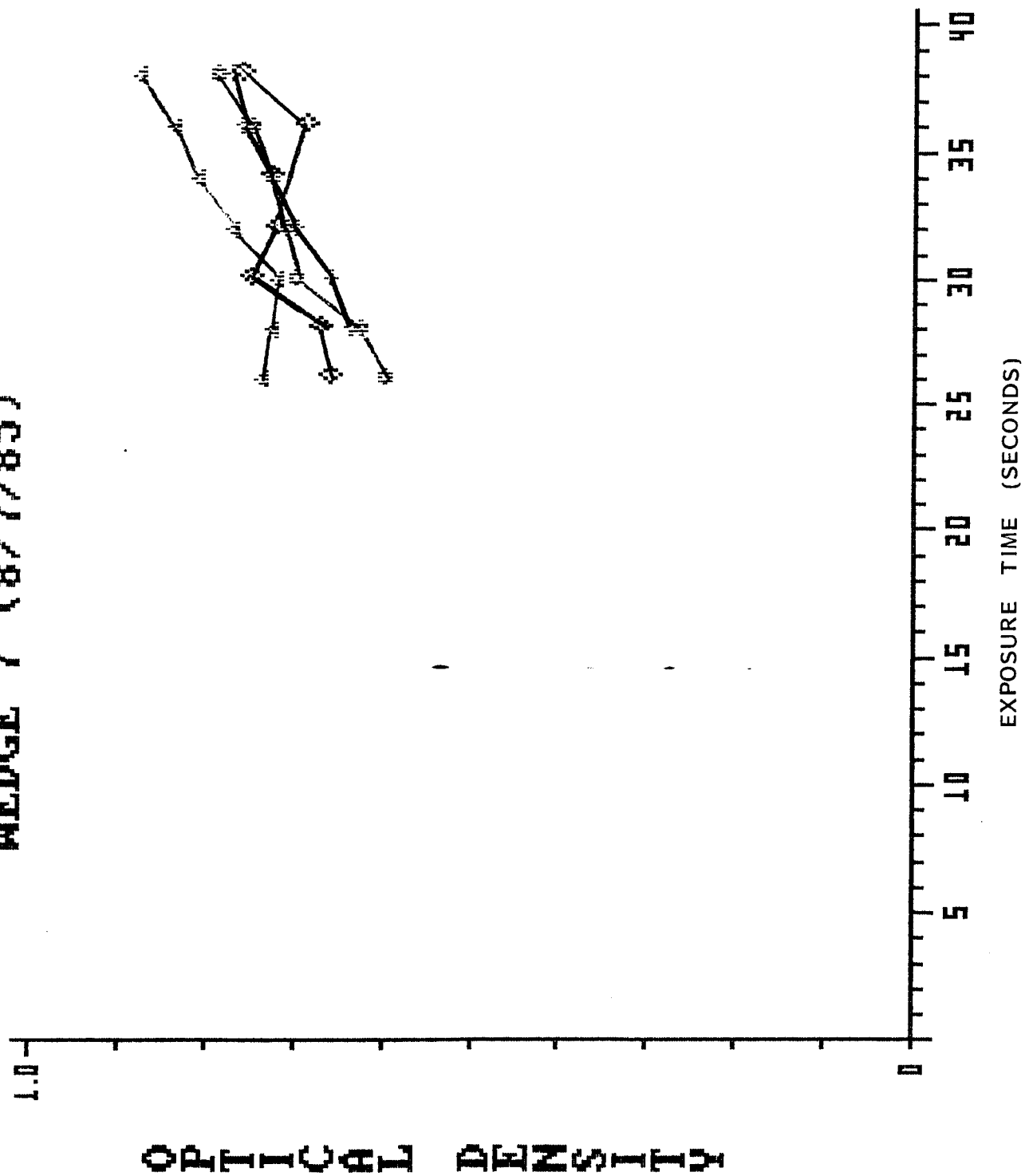


RECIPROCITY FAILURE  
WEDGE 6 (8/7/85)



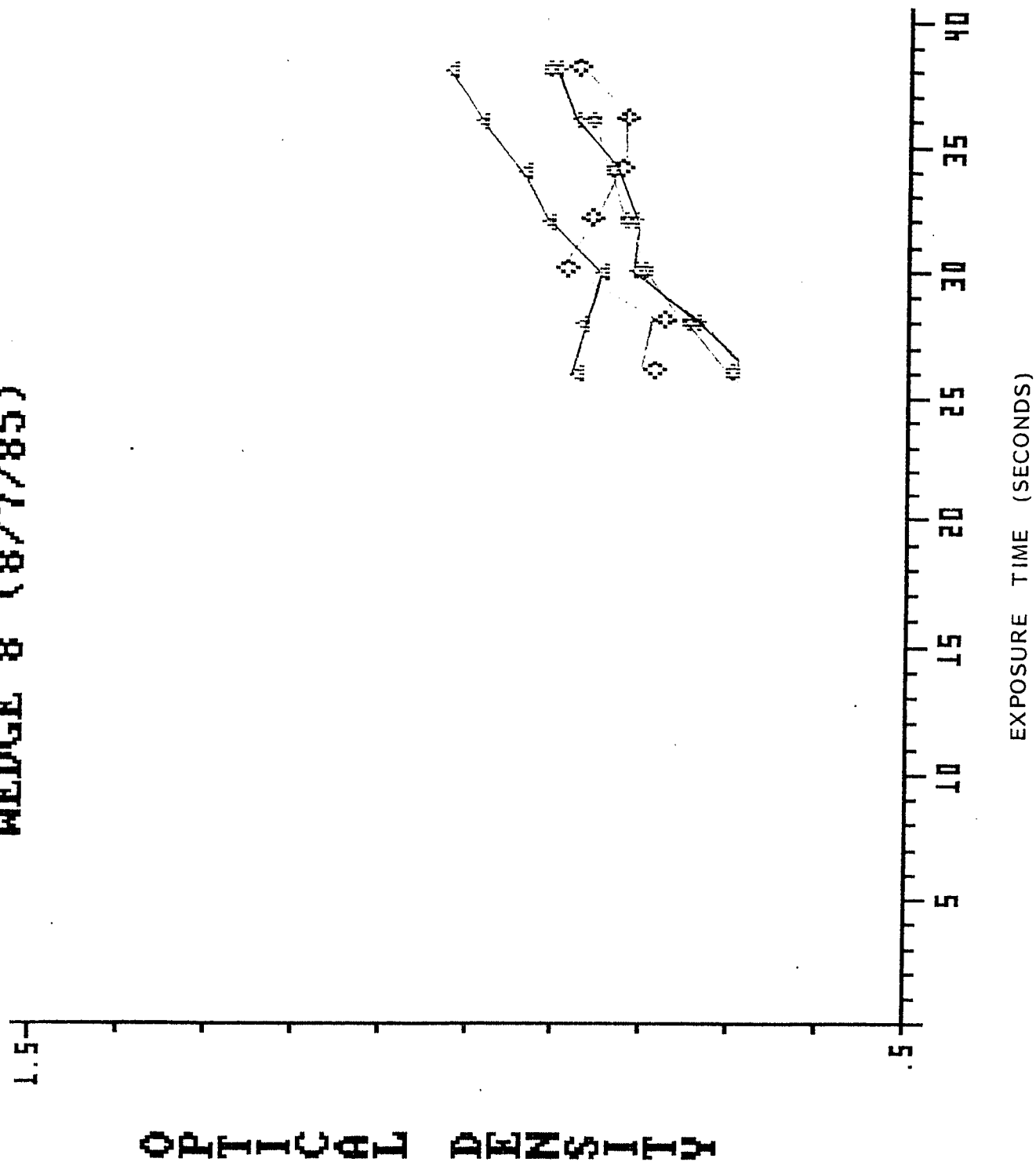
RECIPROCITY FAILURE

WEDGE 7 (8/7/85)



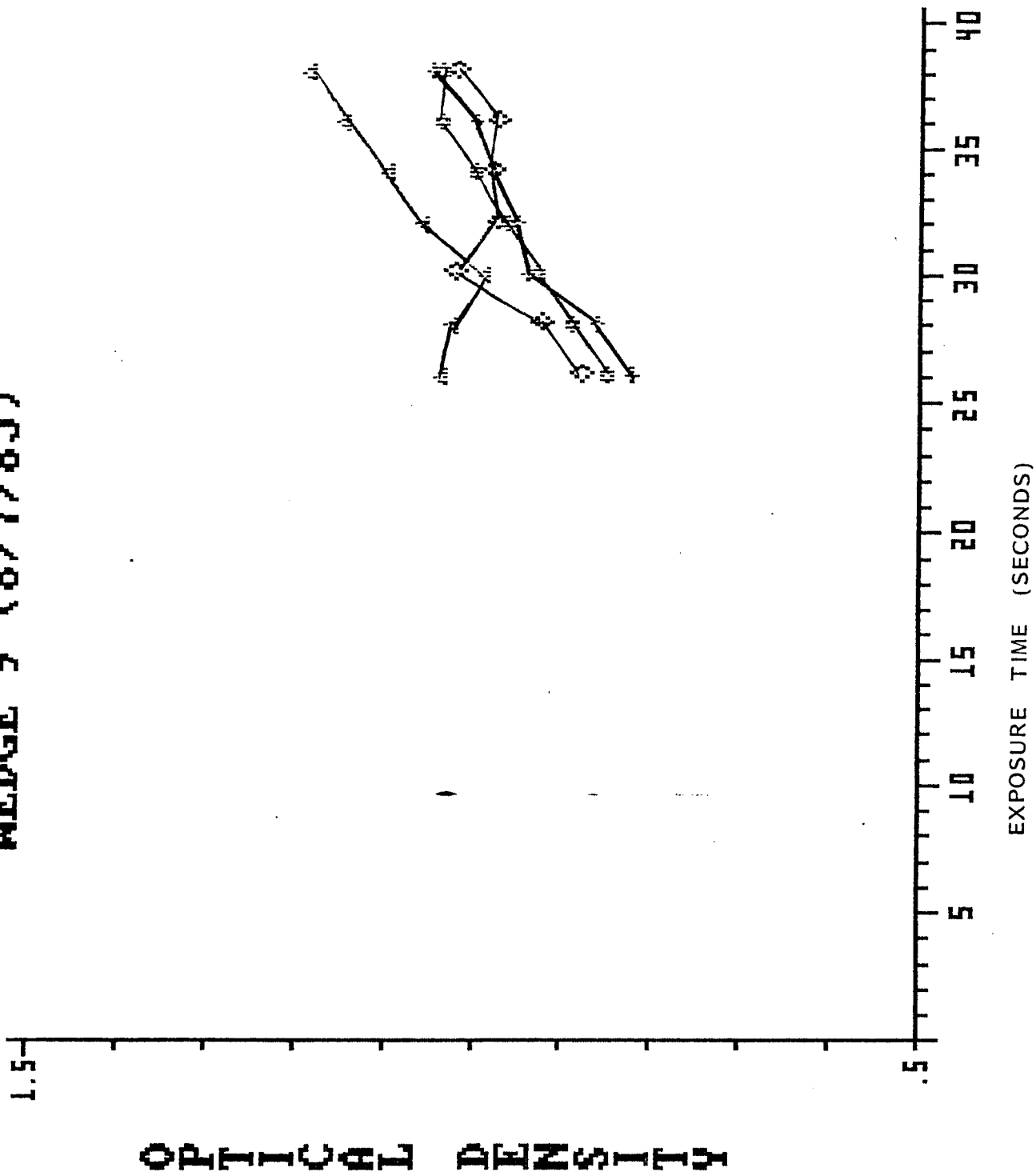
RECIPROCITY FAILURE

WEDGE 8 (8/7/85)



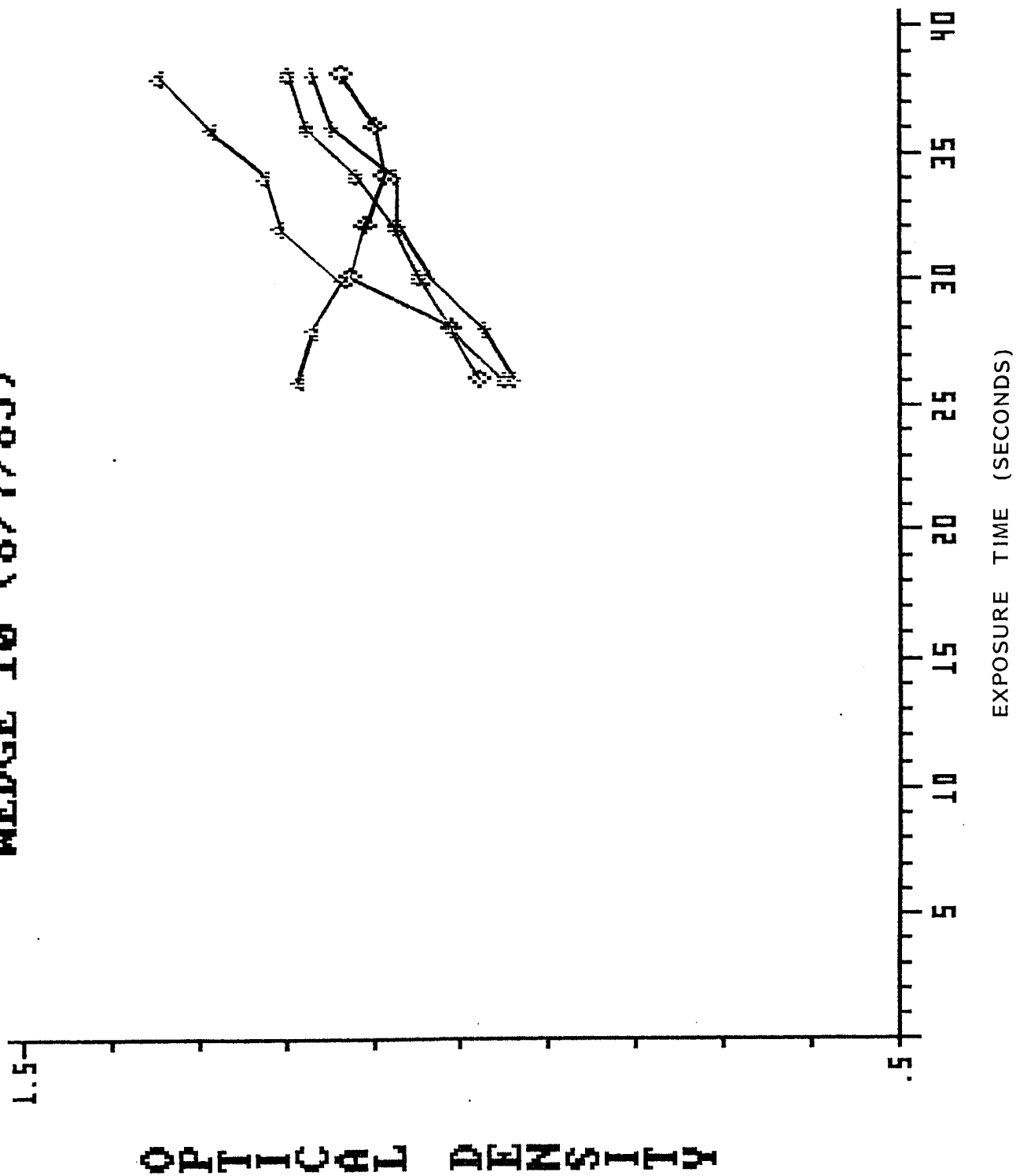
RECIPROCITY FAILURE

WEDGE 9 (8/7/85)



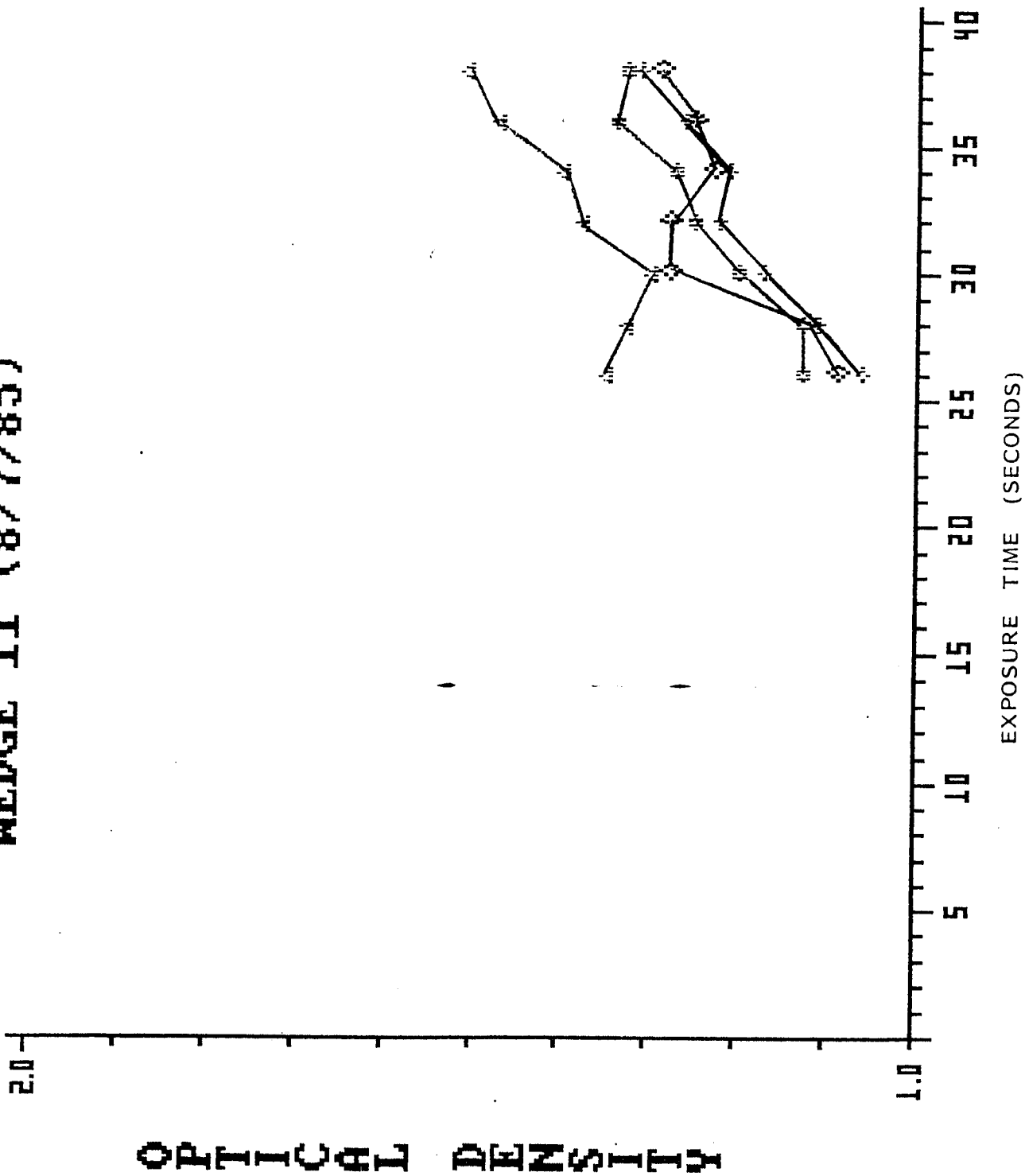
RECIPROCITY FAILURE

WEDGE 10 (8/7/85)



# RECIPROCITY FAILURE

WEDGE 11 (8/7/85)





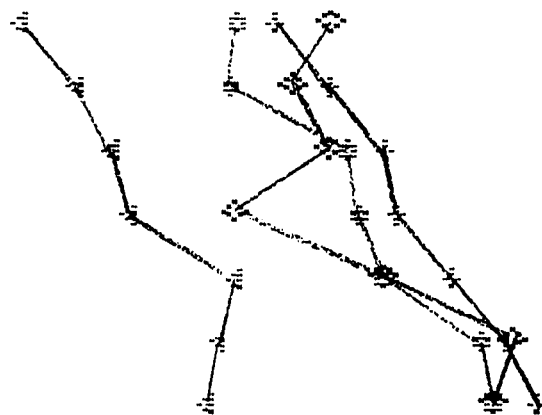
RECIPROCITY FAILURE

WEDGE 12 (8/7/85)

2.0

OPTICAL DENSITY

1.0

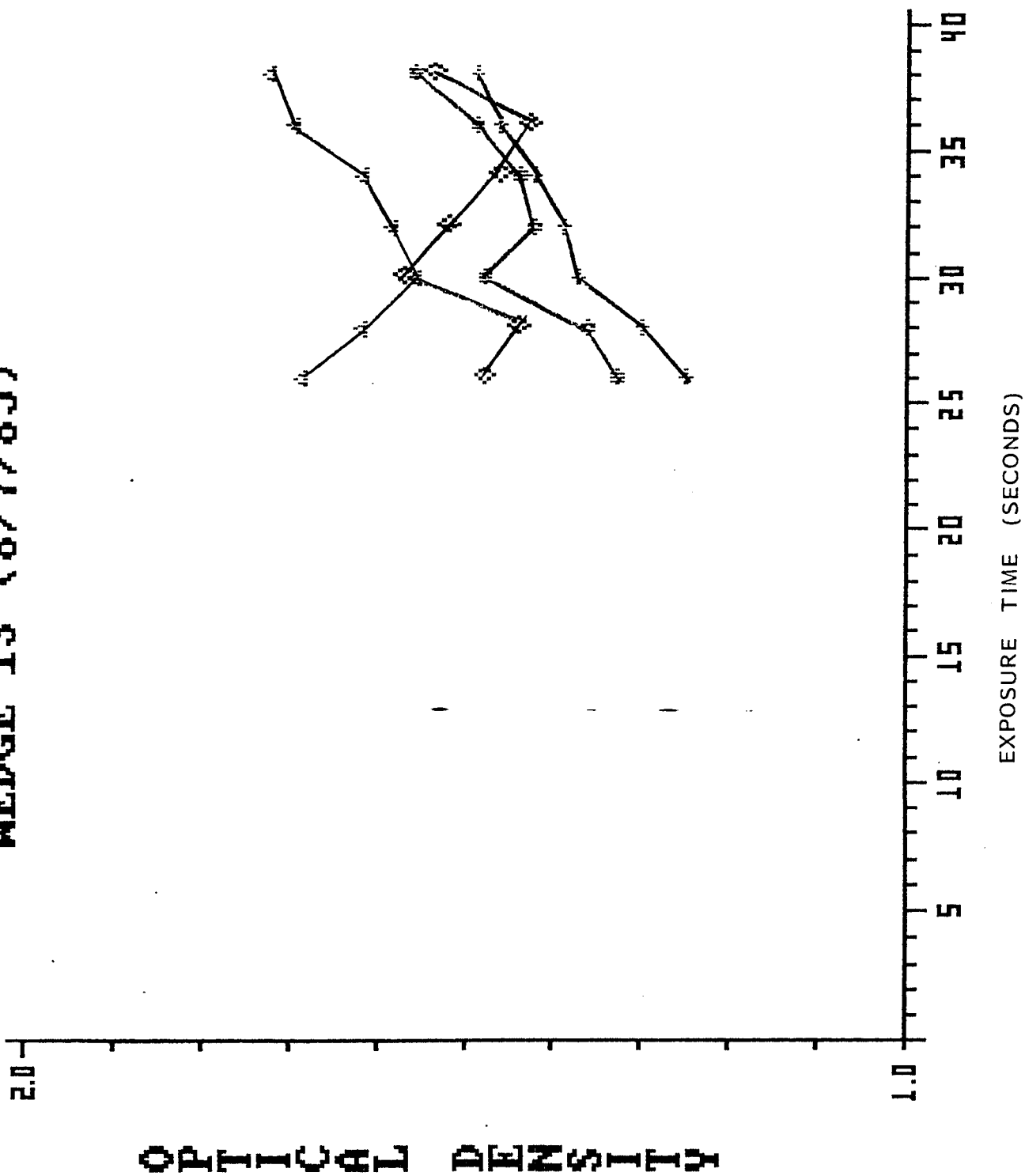


5 10 15 20 25 30 35 40

EXPOSURE TIME (SECONDS)

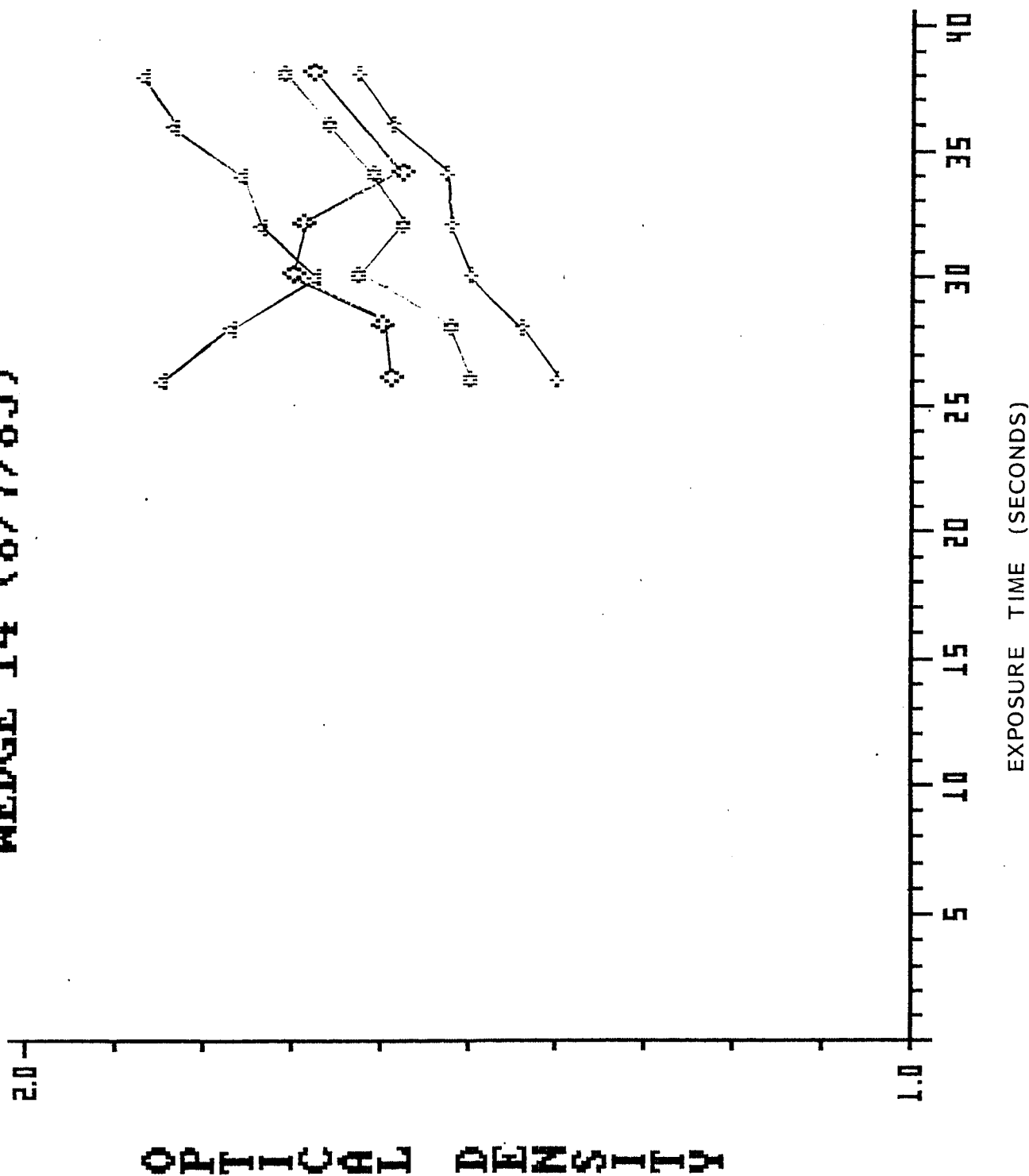
RECIPROCITY FAILURE

WEDGE 13 (8/7/85)



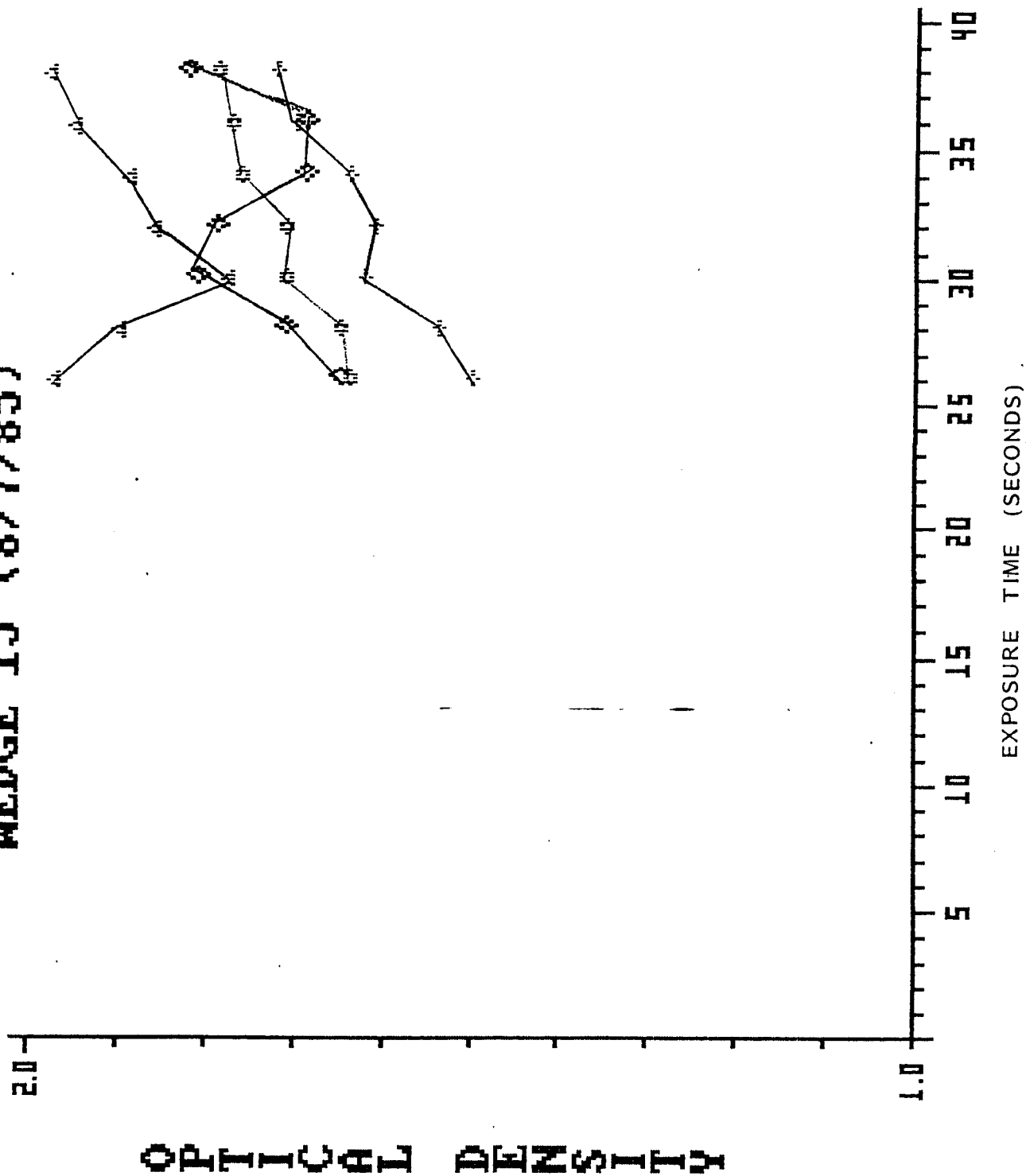
RECIPROCITY FAILURE

WEDGE 14 (8/7/85)



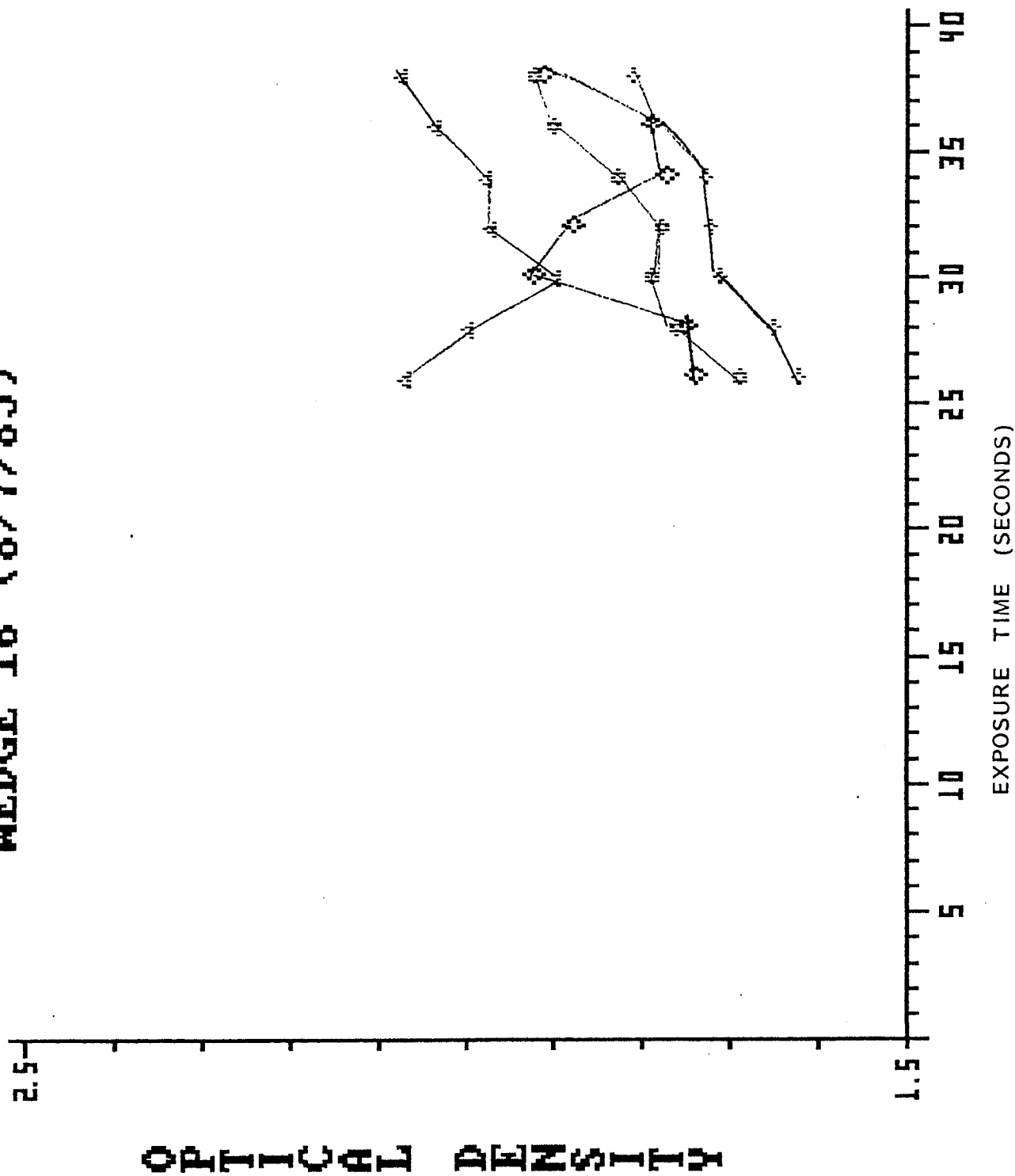
# RECIPROCITY FAILURE

WEDGE 15 (8/7/85)



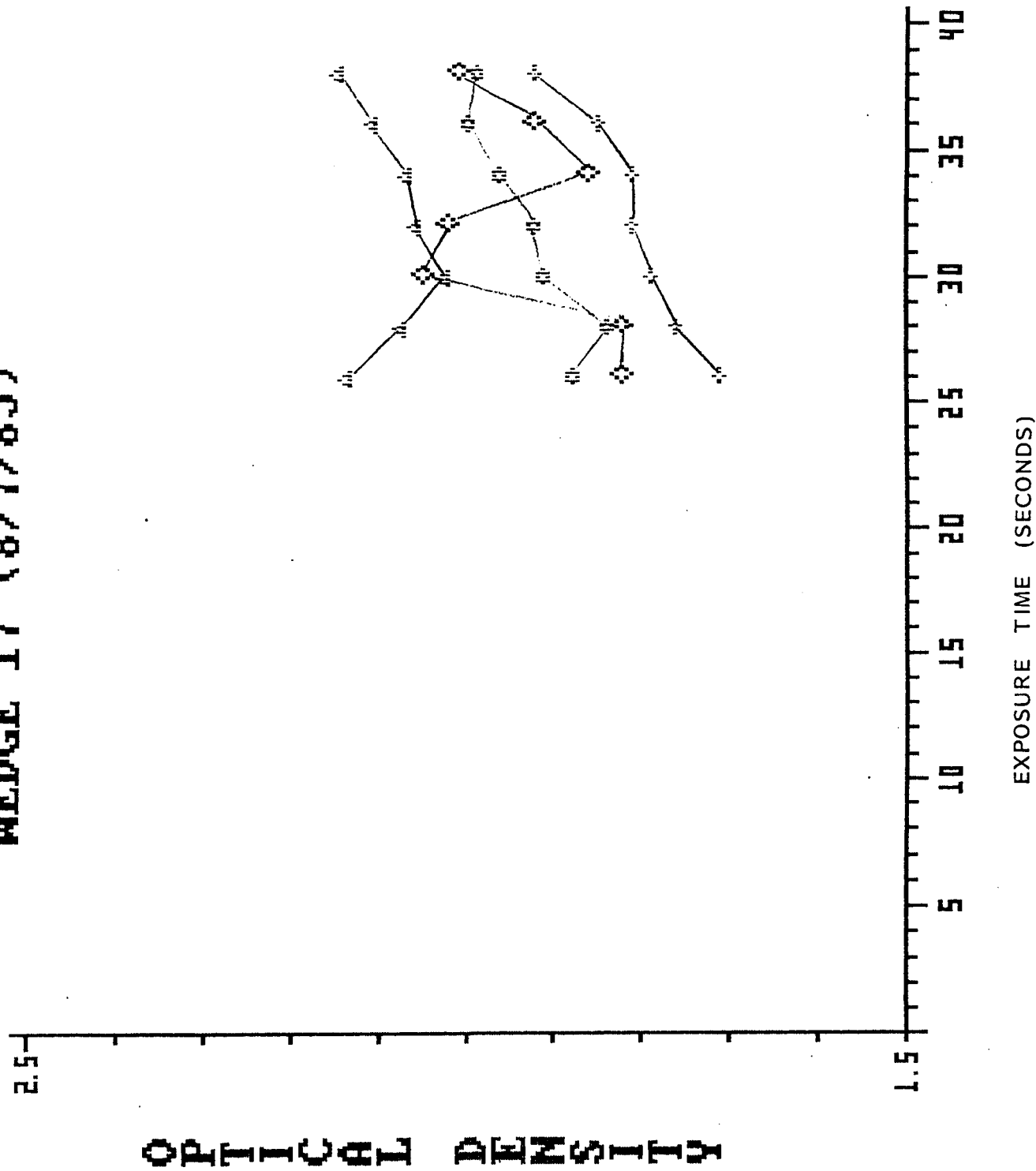
RECIPROCITY FAILURE

WEDGE 16 (8/7/85)



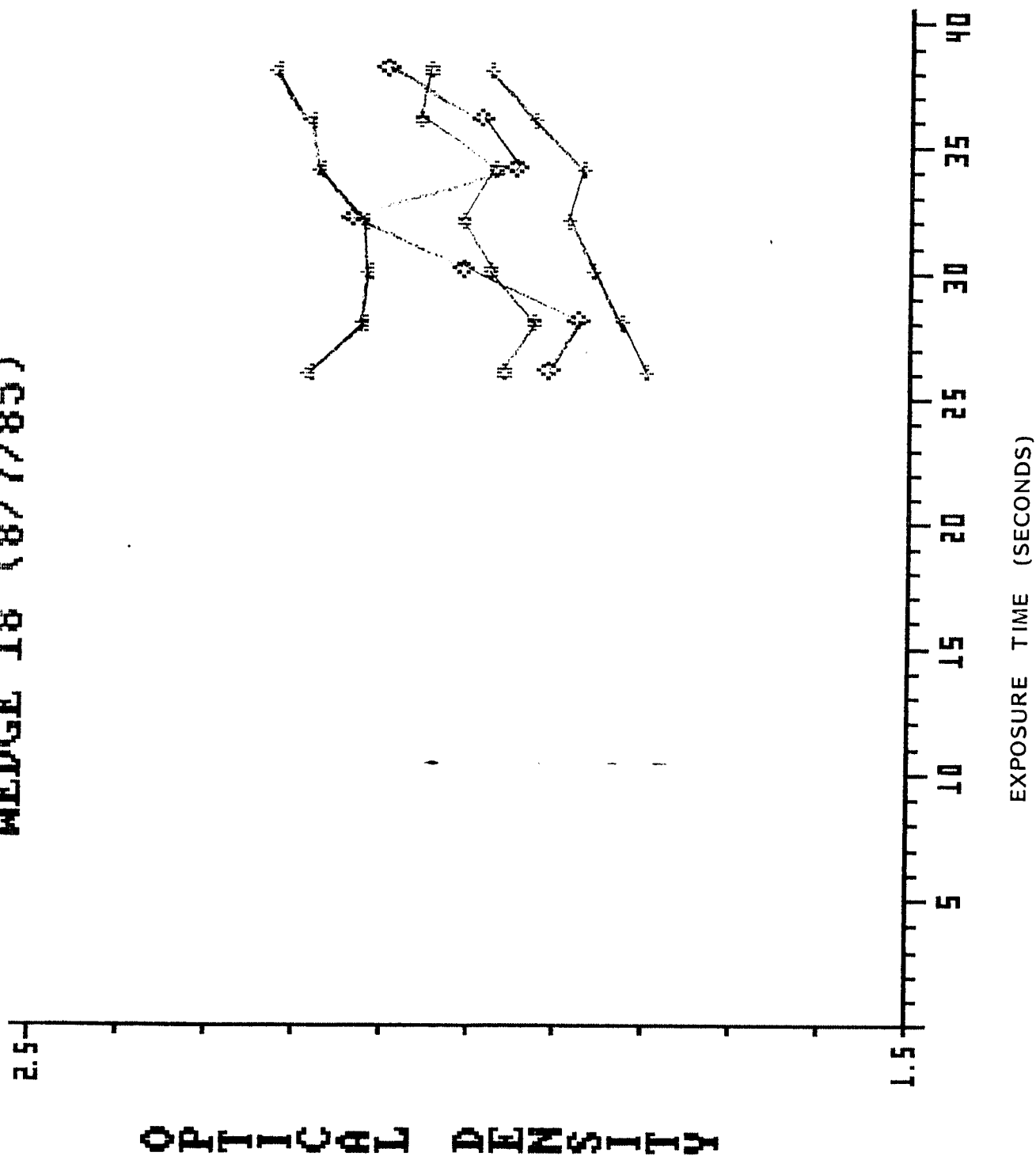
RECIPROCITY FAILURE

WEDGE 17 (8/7/85)



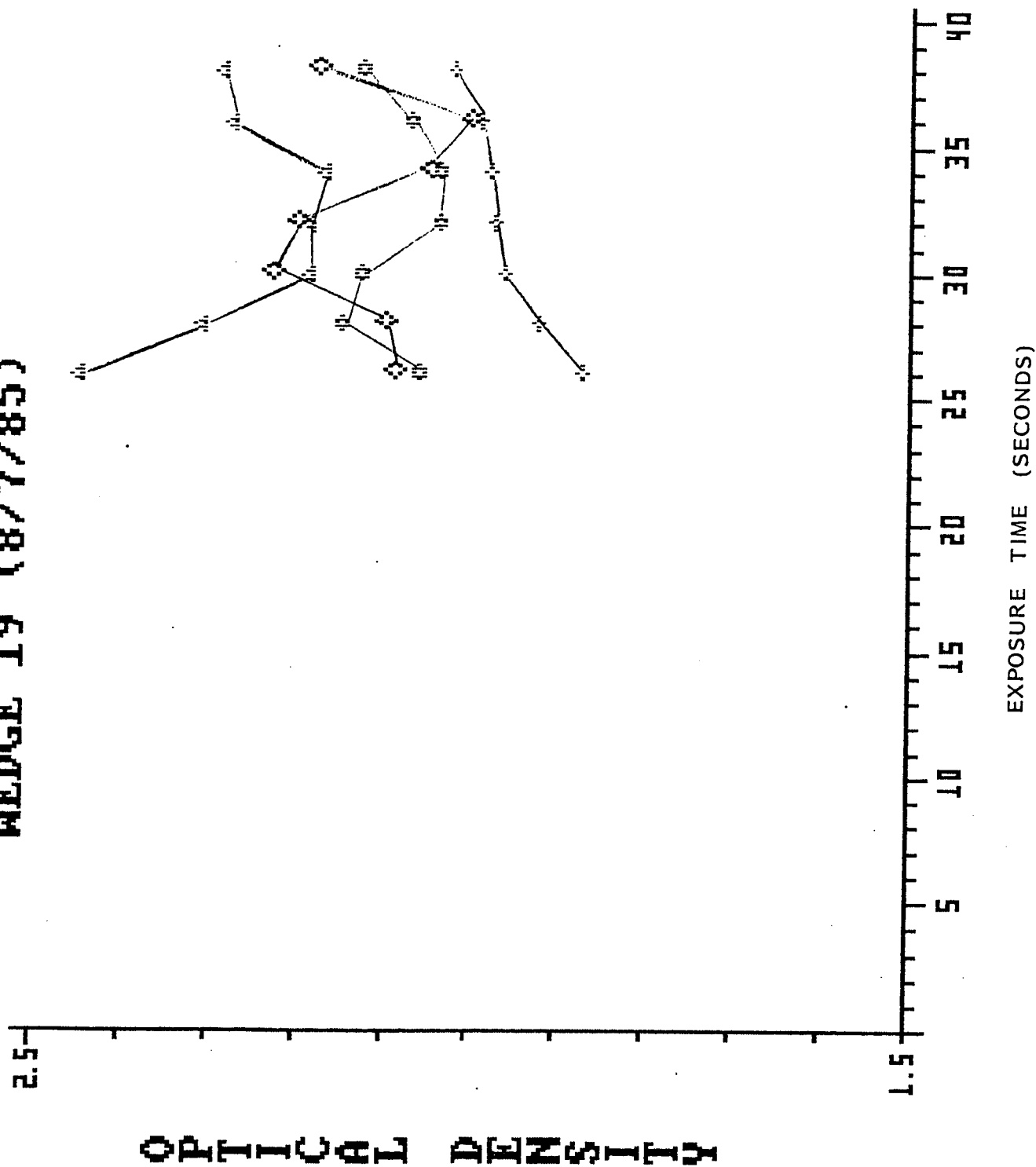
RECIPROCITY FAILURE

WEDGE 18 (8/7/85)



RECIPROCITY FAILURE

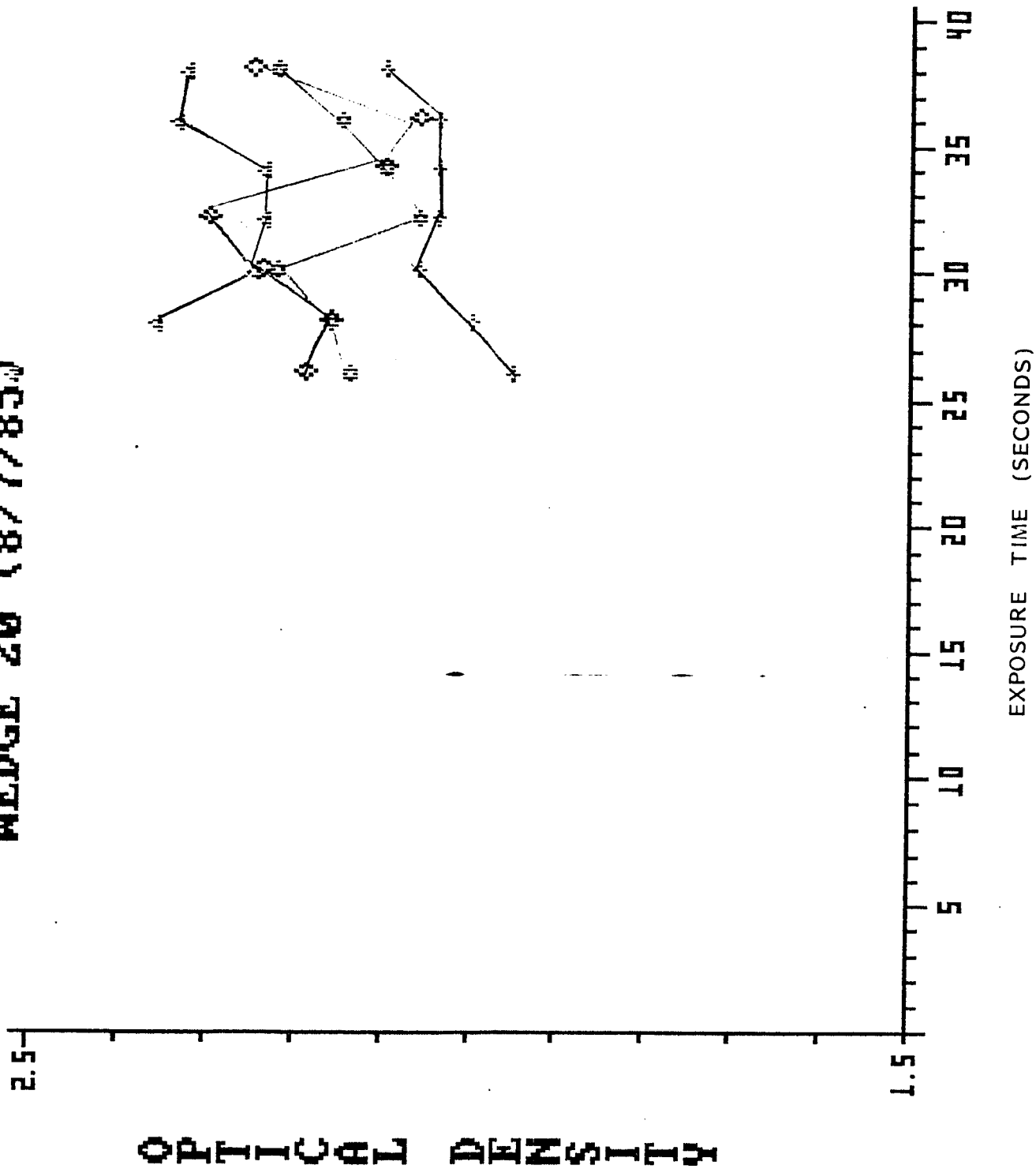
WEDGE 19 (8/7/85)





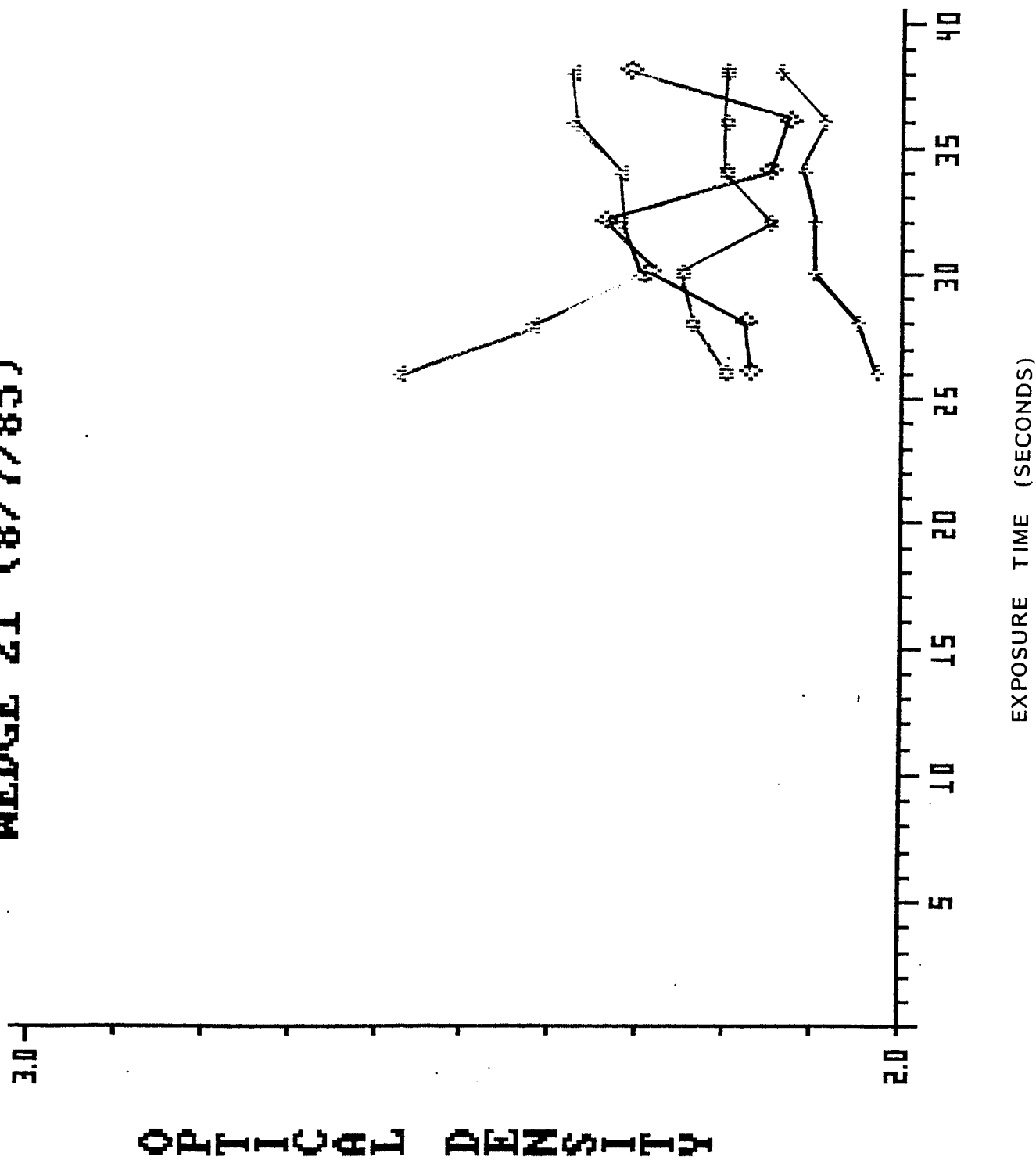
RECIPROCITY FAILURE

WEDGE 20 (8/7/85)



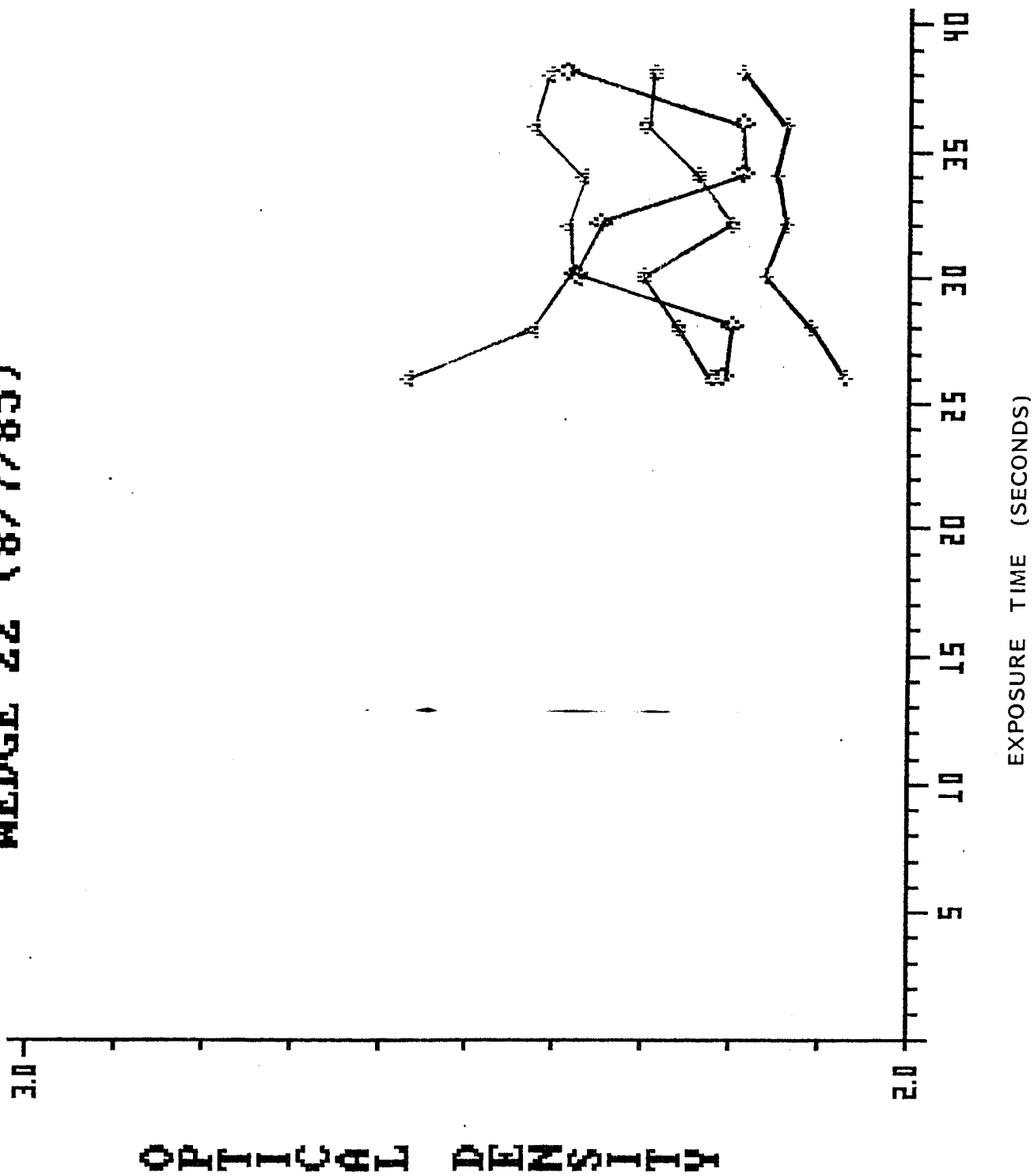
RECIPROCITY FAILURE

WEDGE 21 (8/7/85)



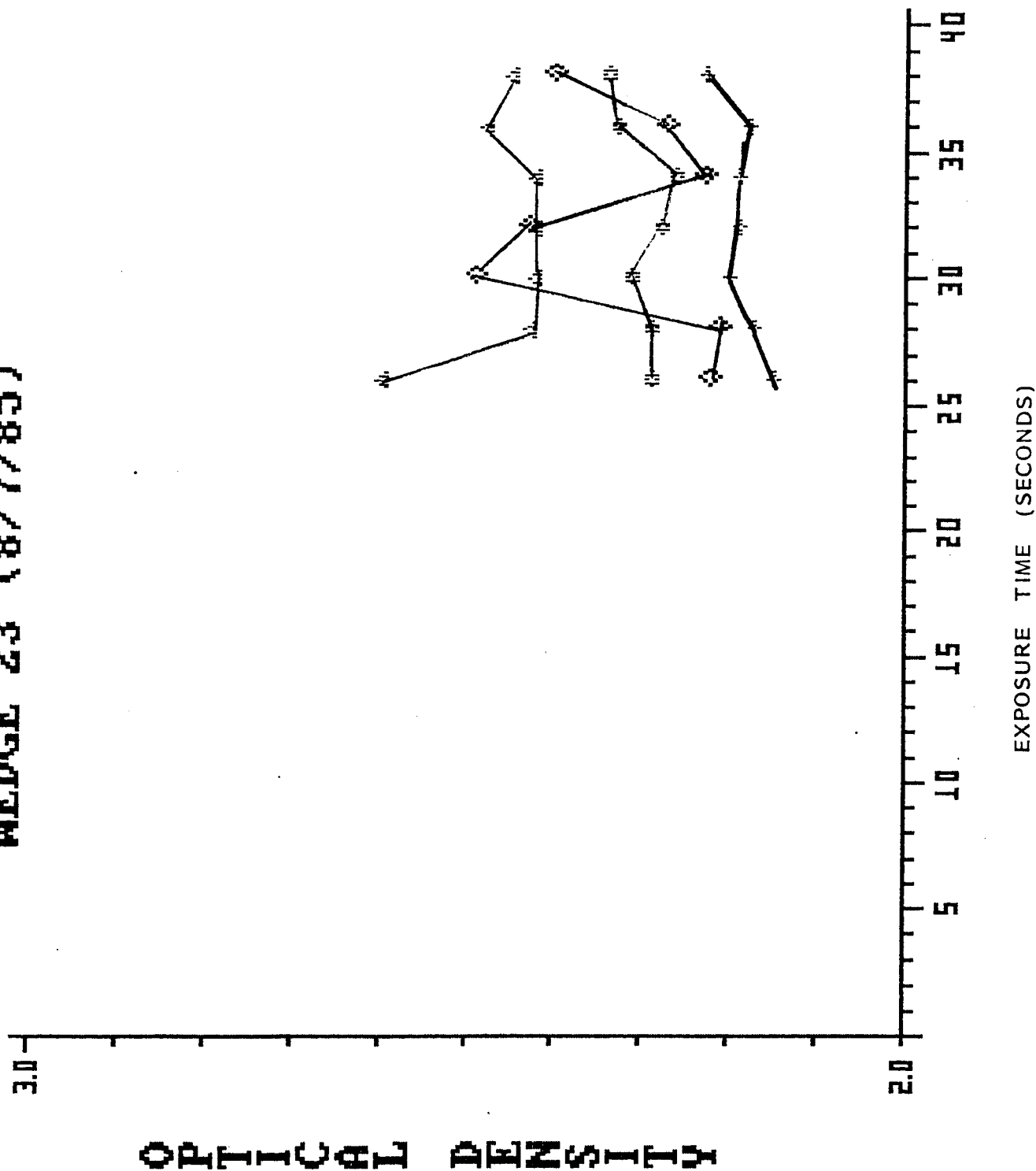
RECIPROCITY FAILURE

WEDGE 22 (8/7/85)



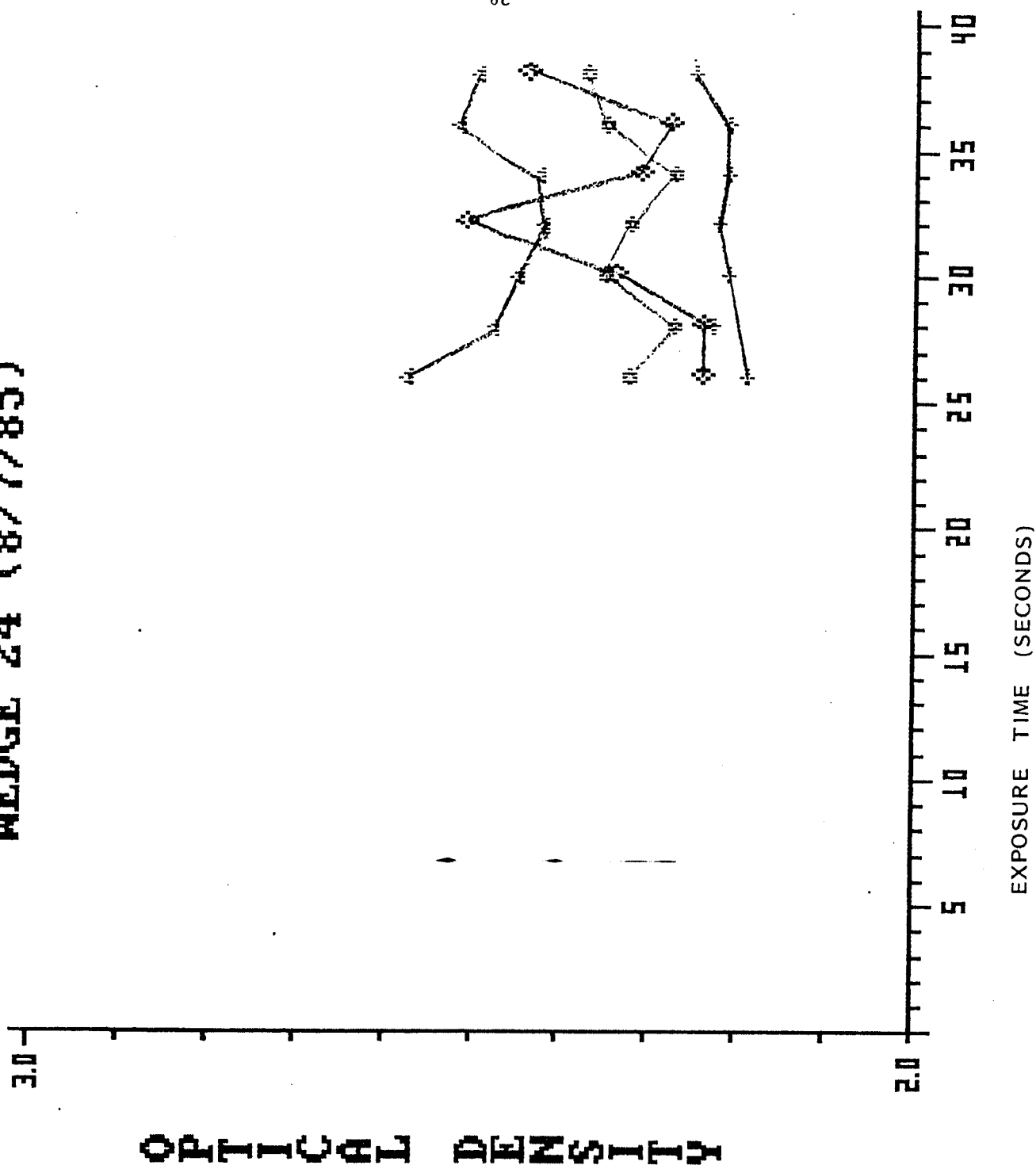
RECIPROCITY FAILURE

WEDGE 23 (8/7/85)



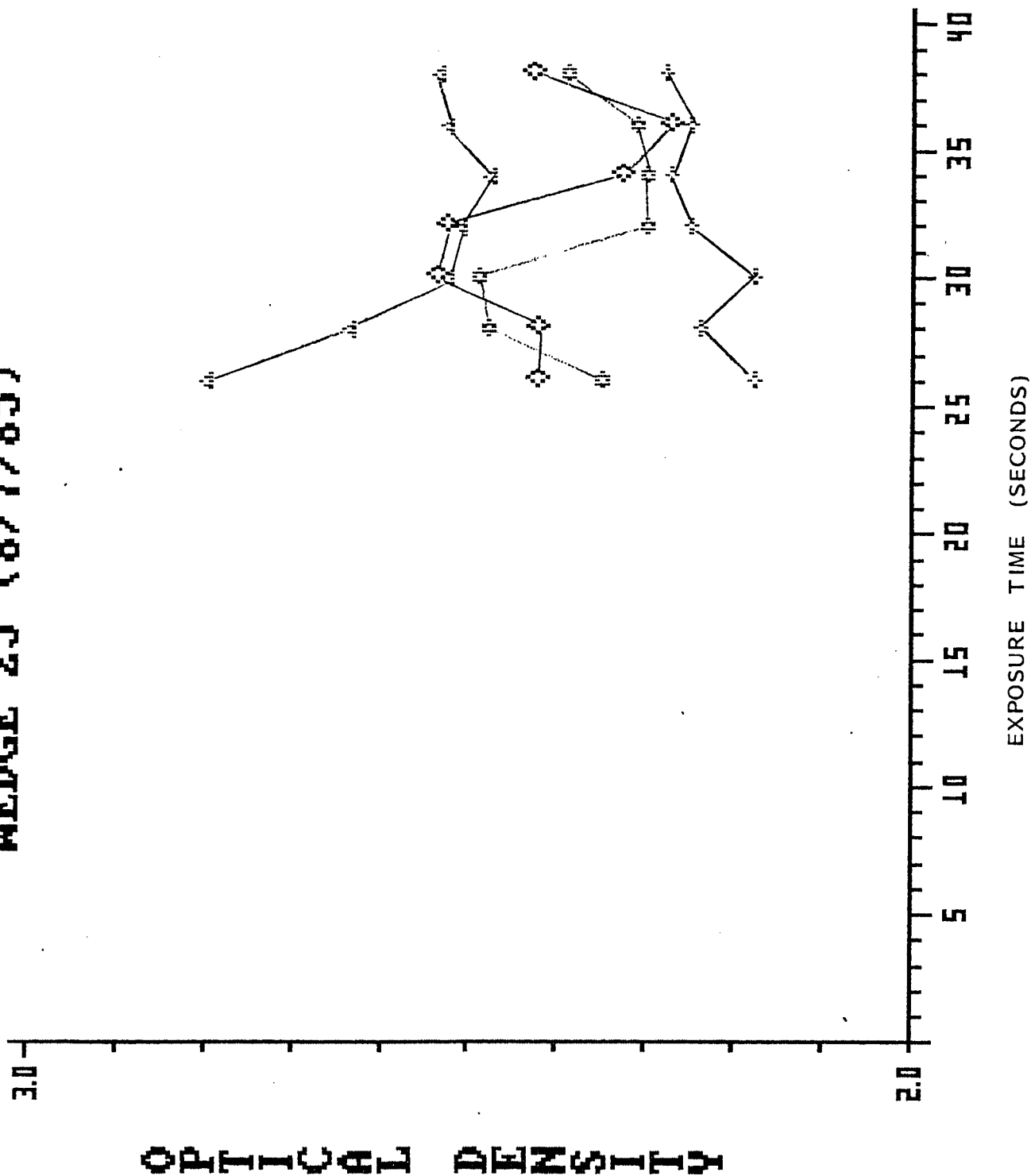
RECIPROCITY FAILURE

WEDGE 24 (8/7/85)



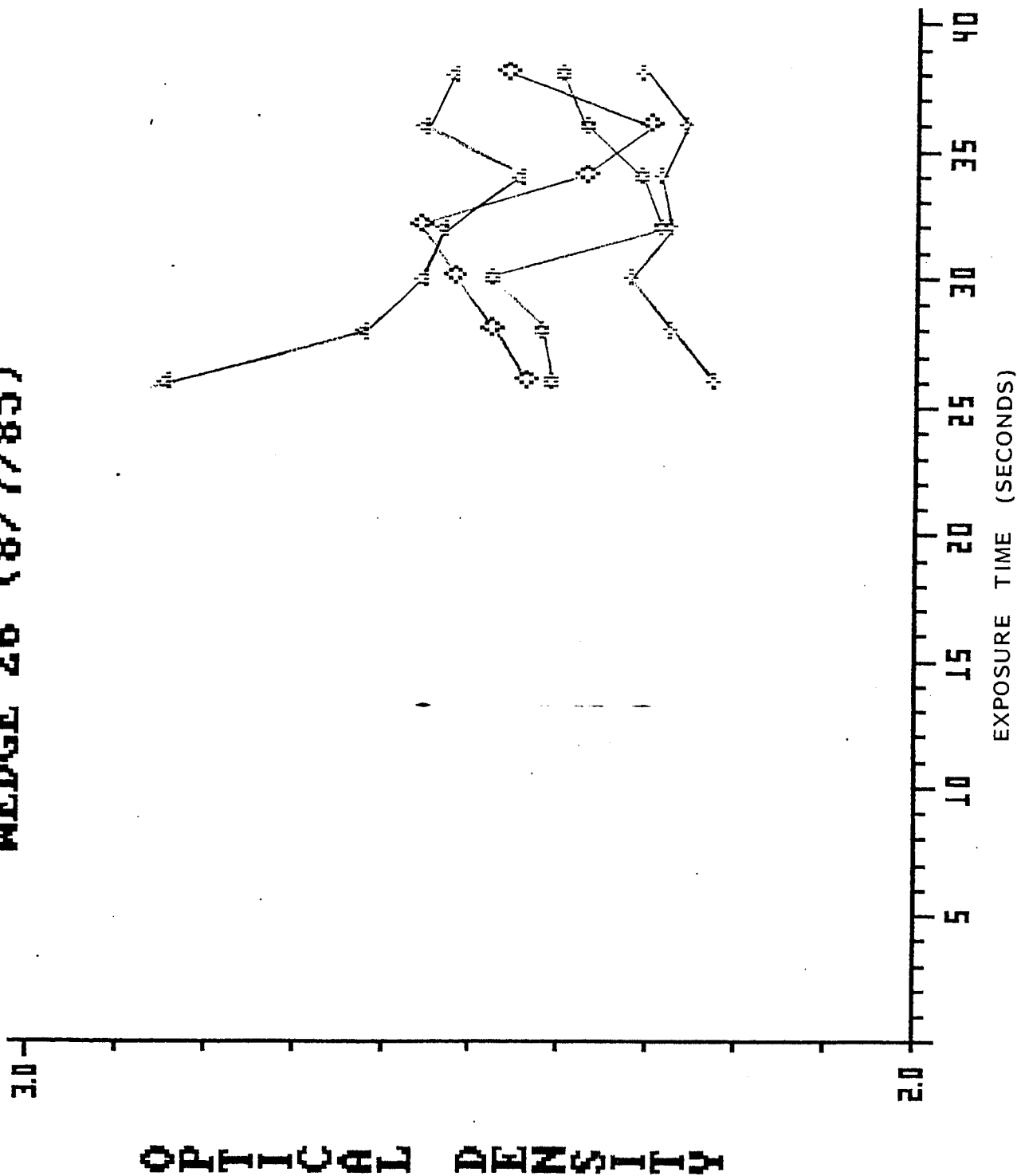
RECIPROCITY FAILURE

WEDGE 25 (8/7/85)



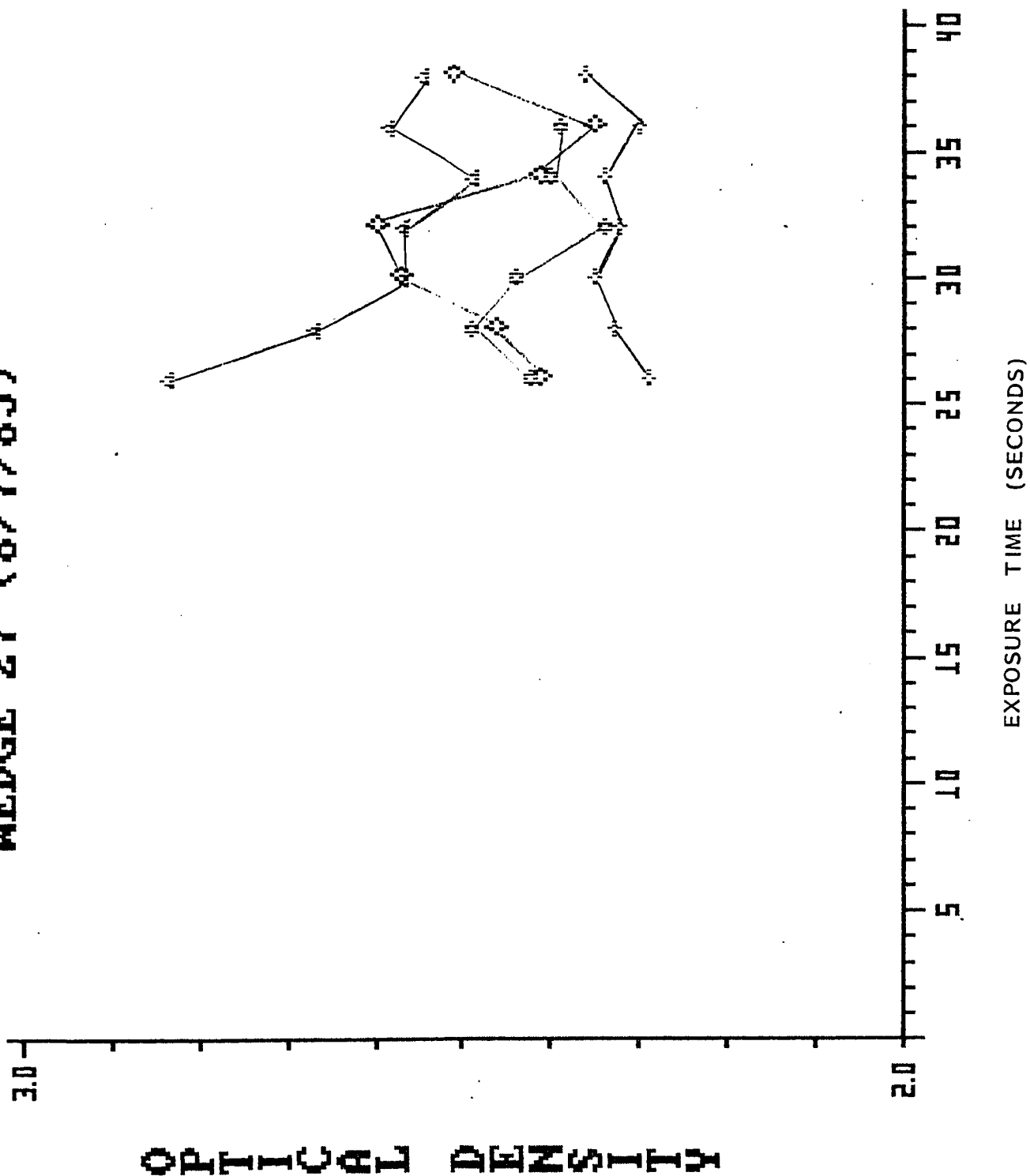
RECIPROCITY FAILURE

WEDGE 26 (8/7/85)



RECIPROCITY FAILURE

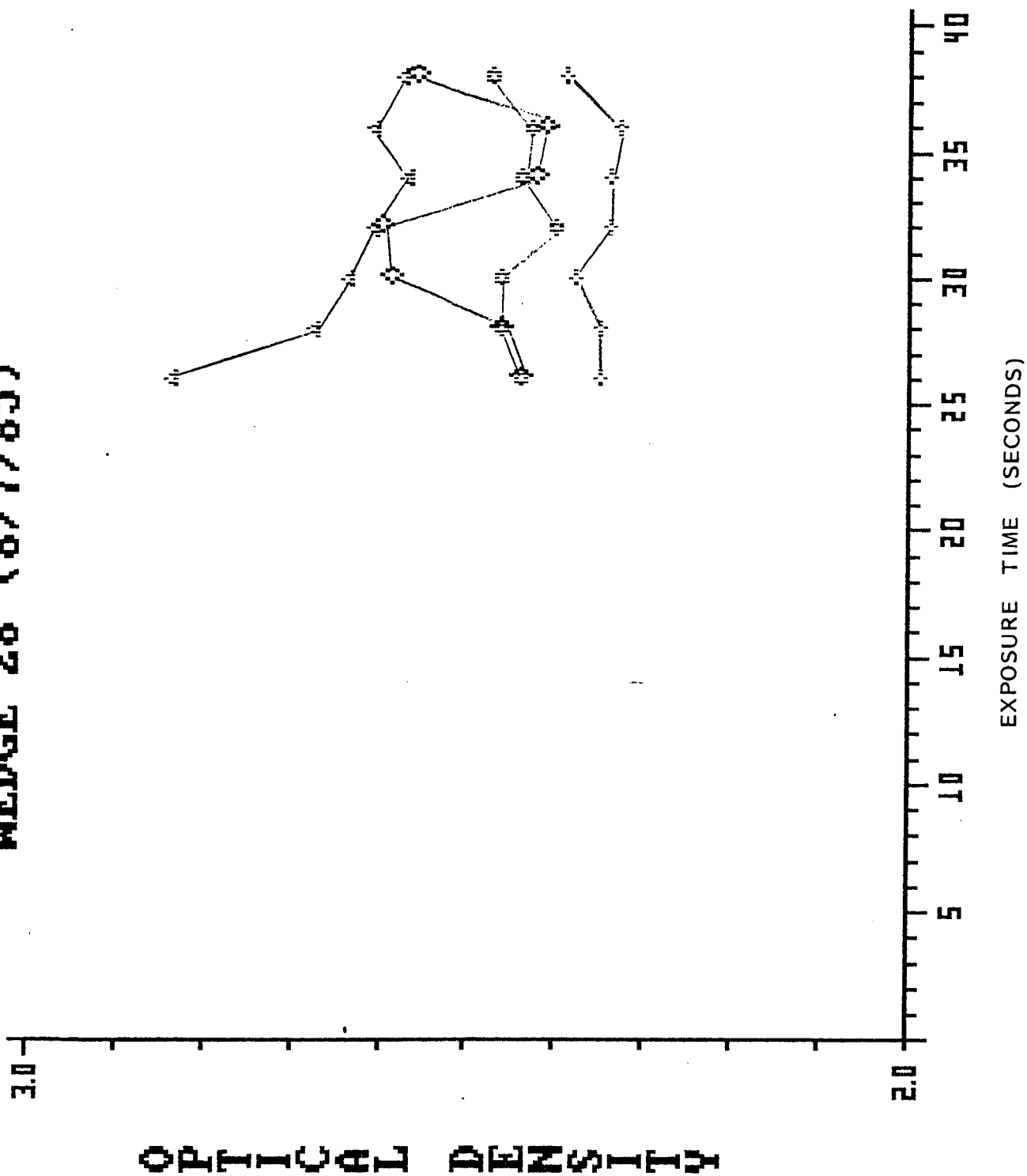
WEDGE 27 (8/7/85)





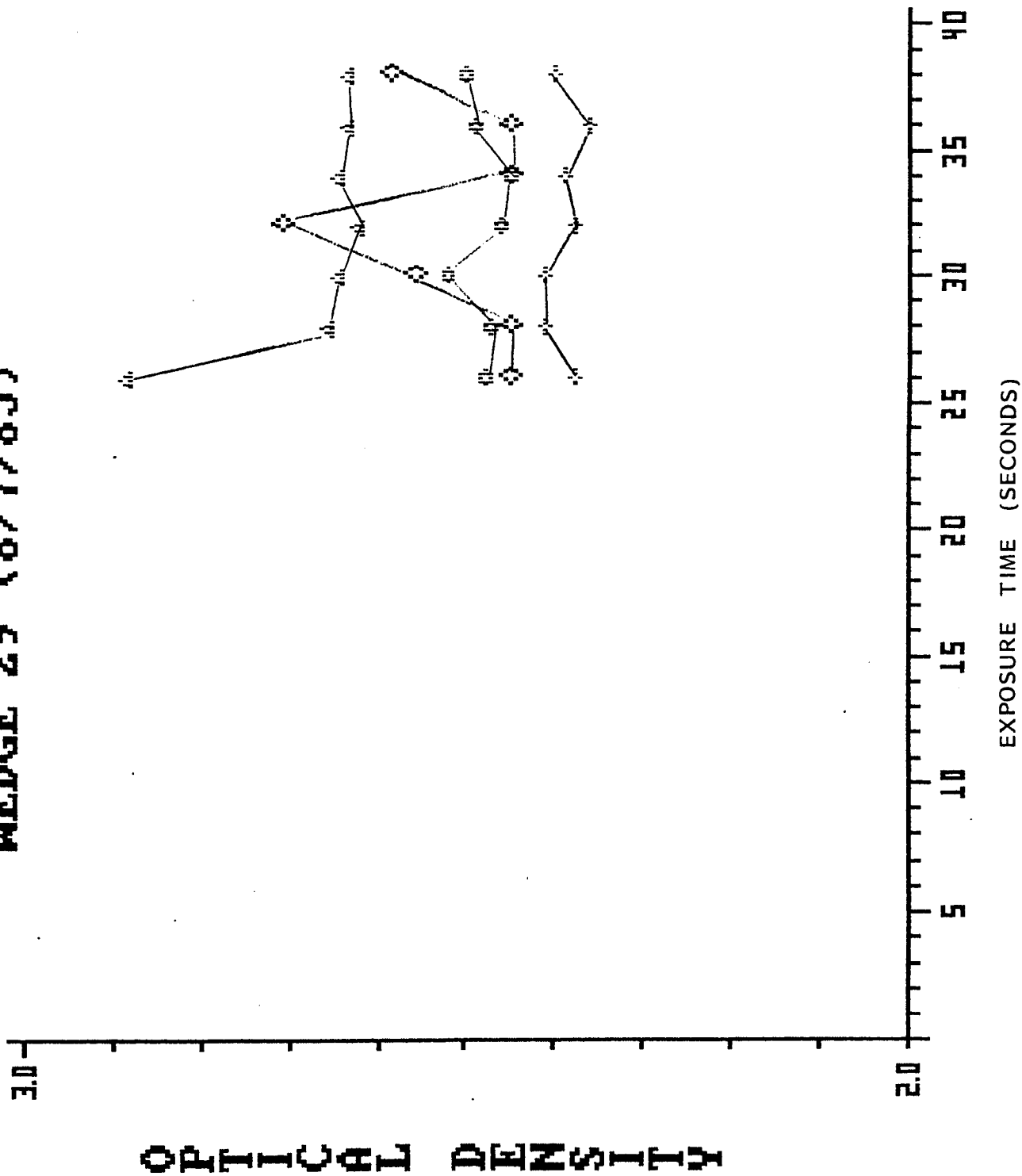
RECIPROCITY FAILURE

WEDGE 28 (8/7/85)

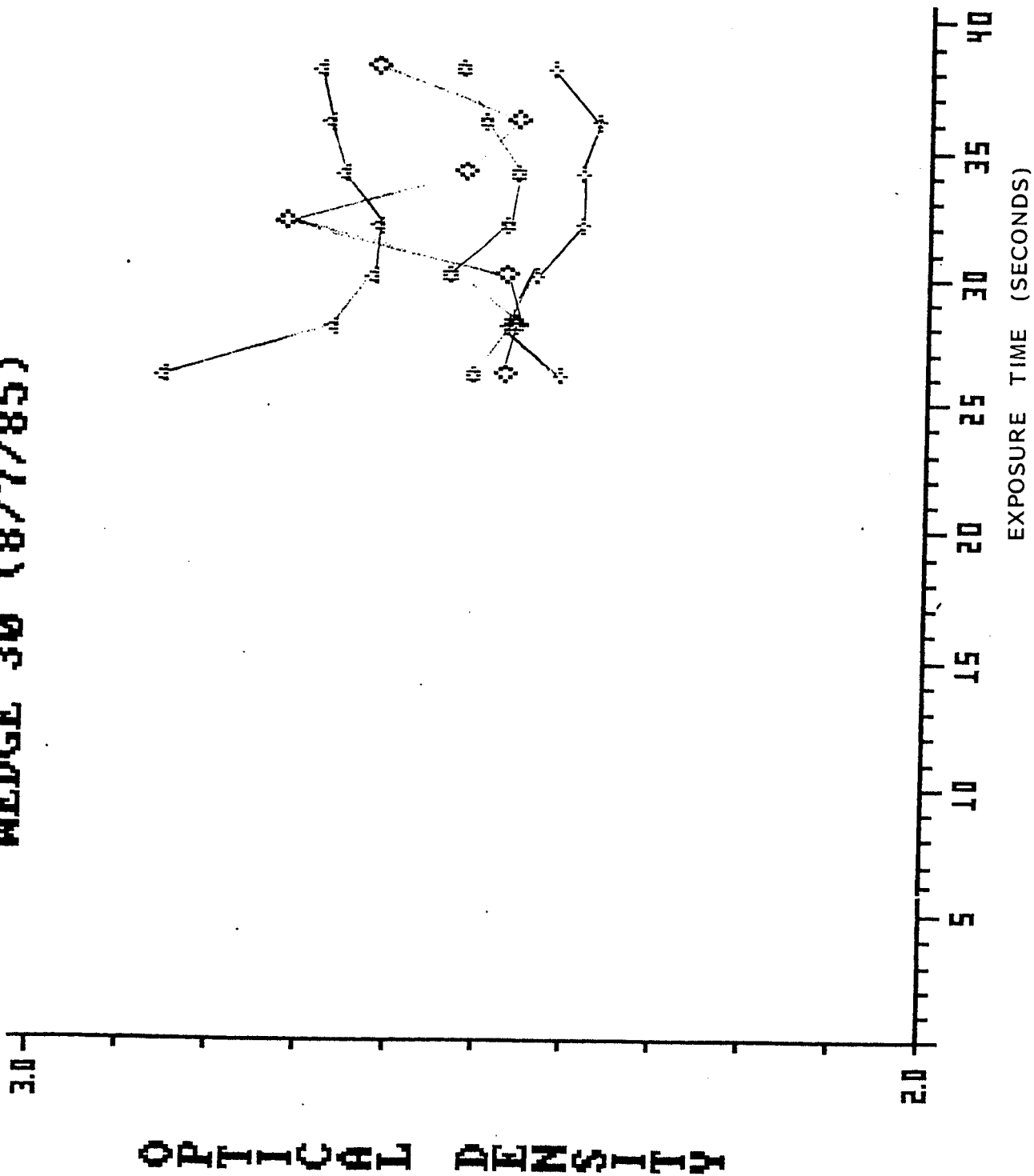


RECIPROCITY FAILURE

WEDGE 29 (8/7/85)



WEDGE 30 (8/7/85)



(B) Thermal and Aging Effects in Relationship to Reciprocity Failure

Three different film samples were used to observe the possible relationship between reciprocity failure and temperature. Temperatures of 31°C and 39°C were chosen for this initial study. The three different samples were taken from three different batches. The three different film samples were identified as samples one, two and three. Film samples two and three were aged samples of film, whereas film sample one was relatively new compared with the other two samples. For this study, exposure times of 25, 27, 30, 33, 35 and 38 were chosen to detect reciprocity failure. Film samples one and two were incubated for a period of one hour at 39°C and film sample three was incubated at 31°C for a period of one hour.

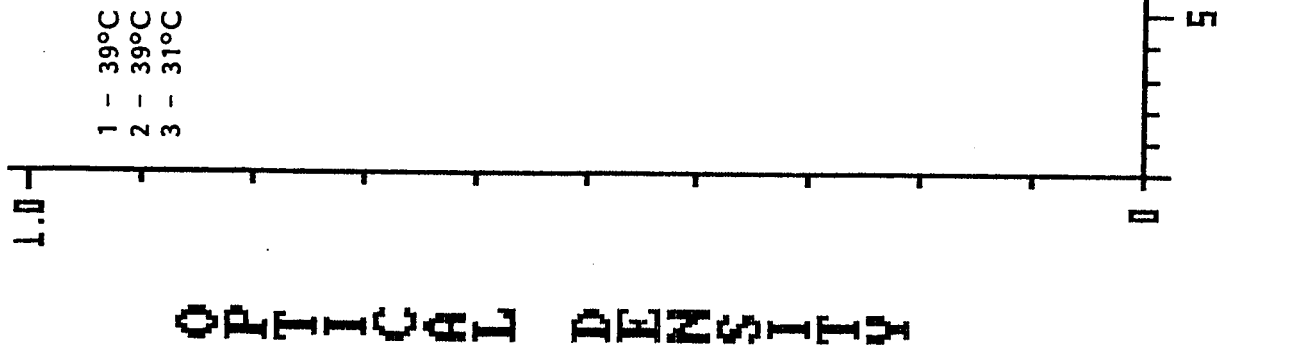
Each film sample was developed and the optical densities were measured by a MacBeth Densitometer. The densities were then graphed by an IBM personal computer. Each individual wedge for each film sample was graphed as optical density vs. time.

## RESULTS

The results of this experiment indicate that the oldest aged film batch incubated at 31°C displayed higher densities and more dramatic reciprocity failure than the newer batches that had been exposed to 39°C for a one hour incubating period. (see graphs 1 - 5). This indicates that reciprocity failure is effected more by aging of film than small temperature variations. The age differences in the film was approximately four months and the temperature differences of the film batches was 8°C.

RECIPROCITY FAILURE

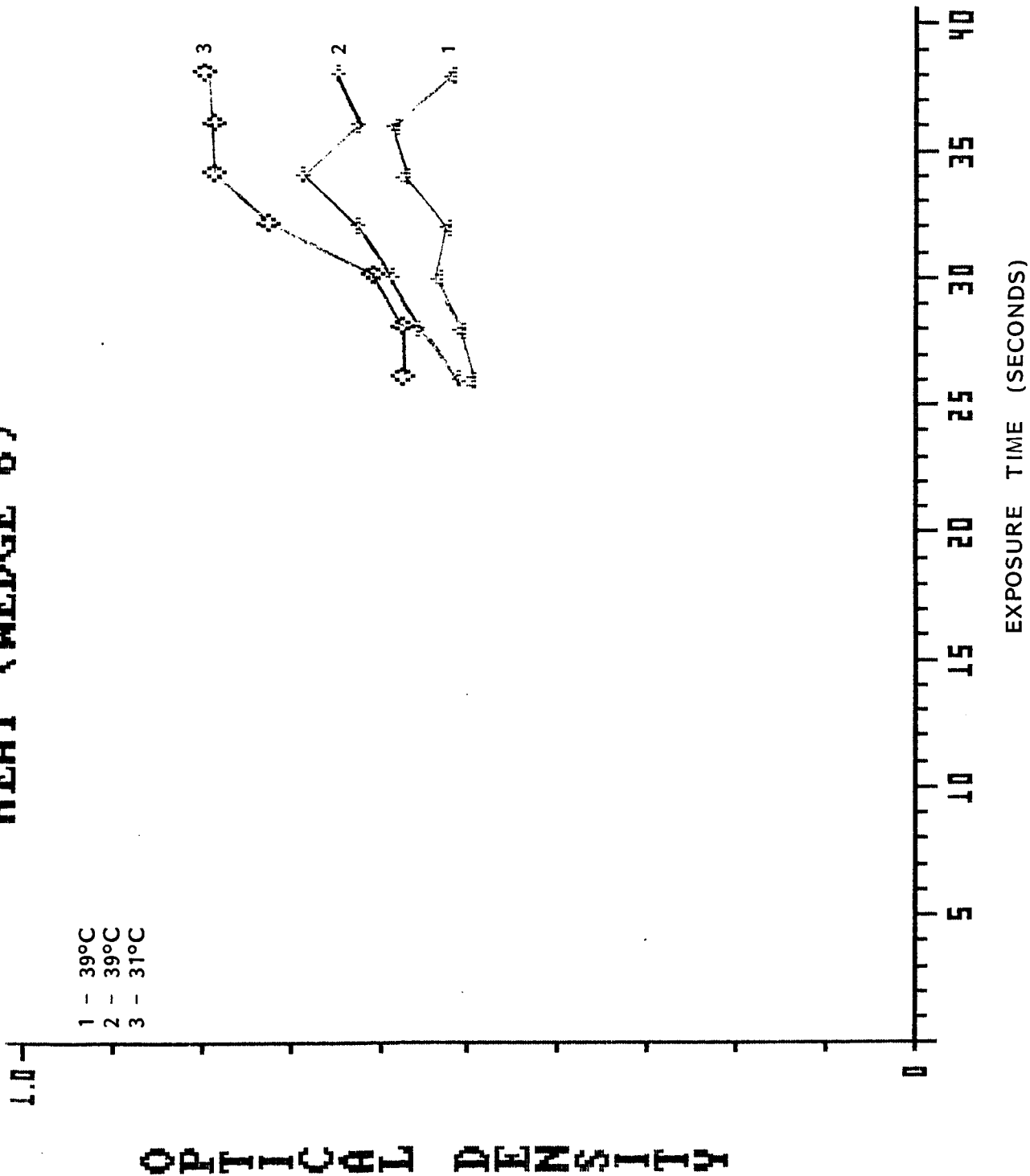
# HEAT (WEDGE 4)



GRAPH #1

# RECIPROCITY FAILURE

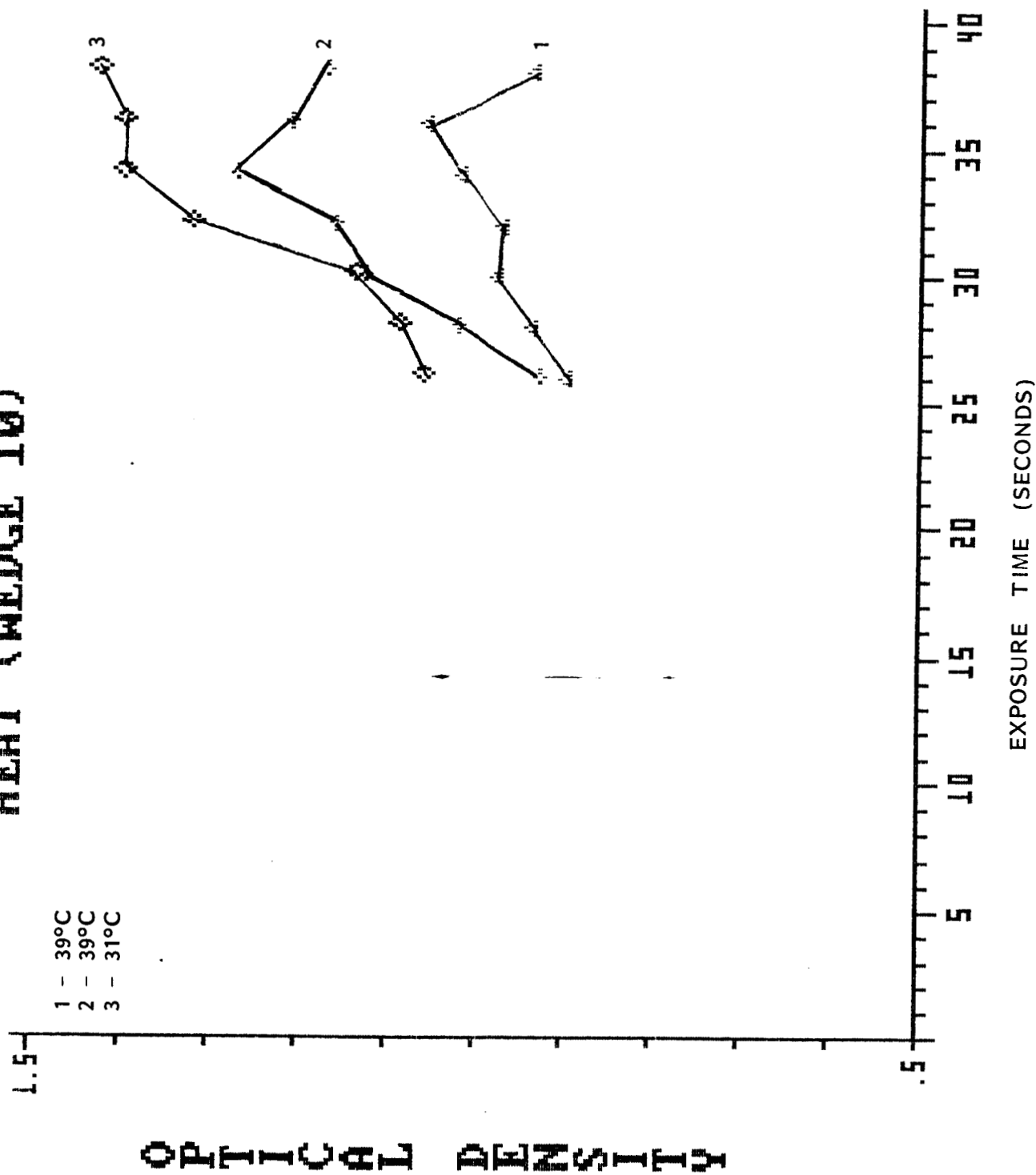
## HEAT (WEDGE 6)



GRAPH #2

# RECIPROCITY FAILURE

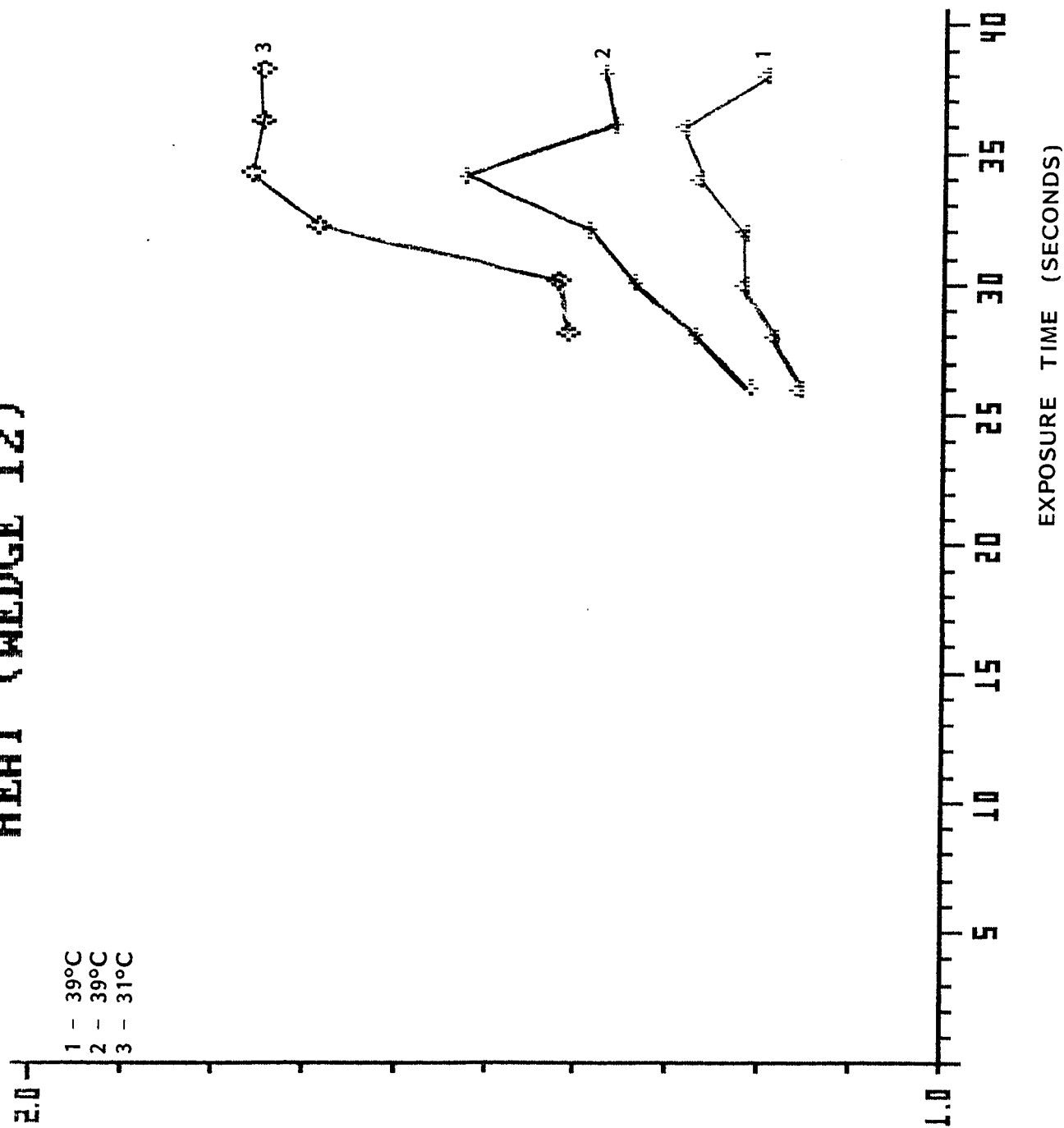
## HEAT (WEDGE 10)



GRAPH #3

# RECIPROCITY FAILURE

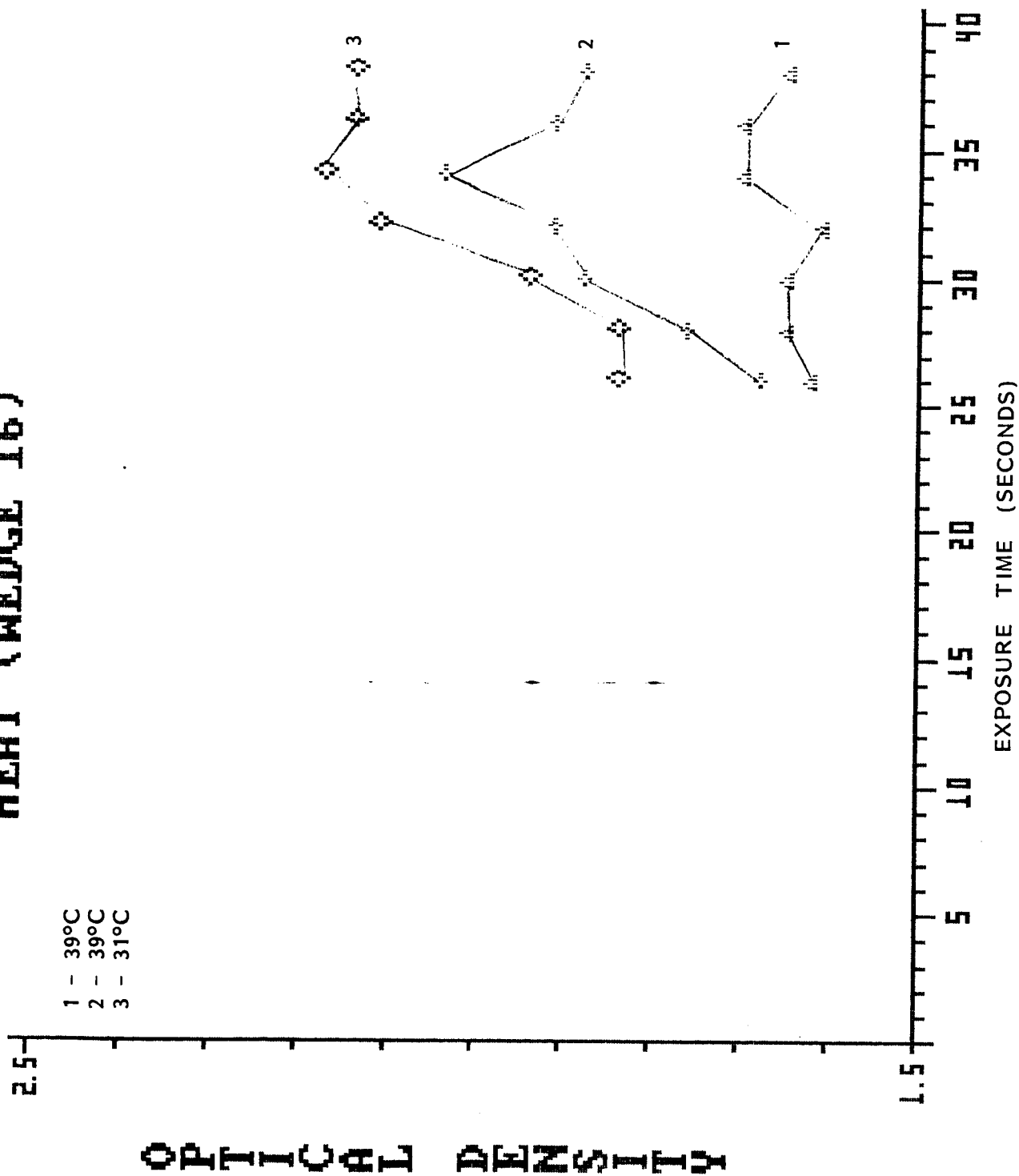
## HEAT (WEDGE 12)



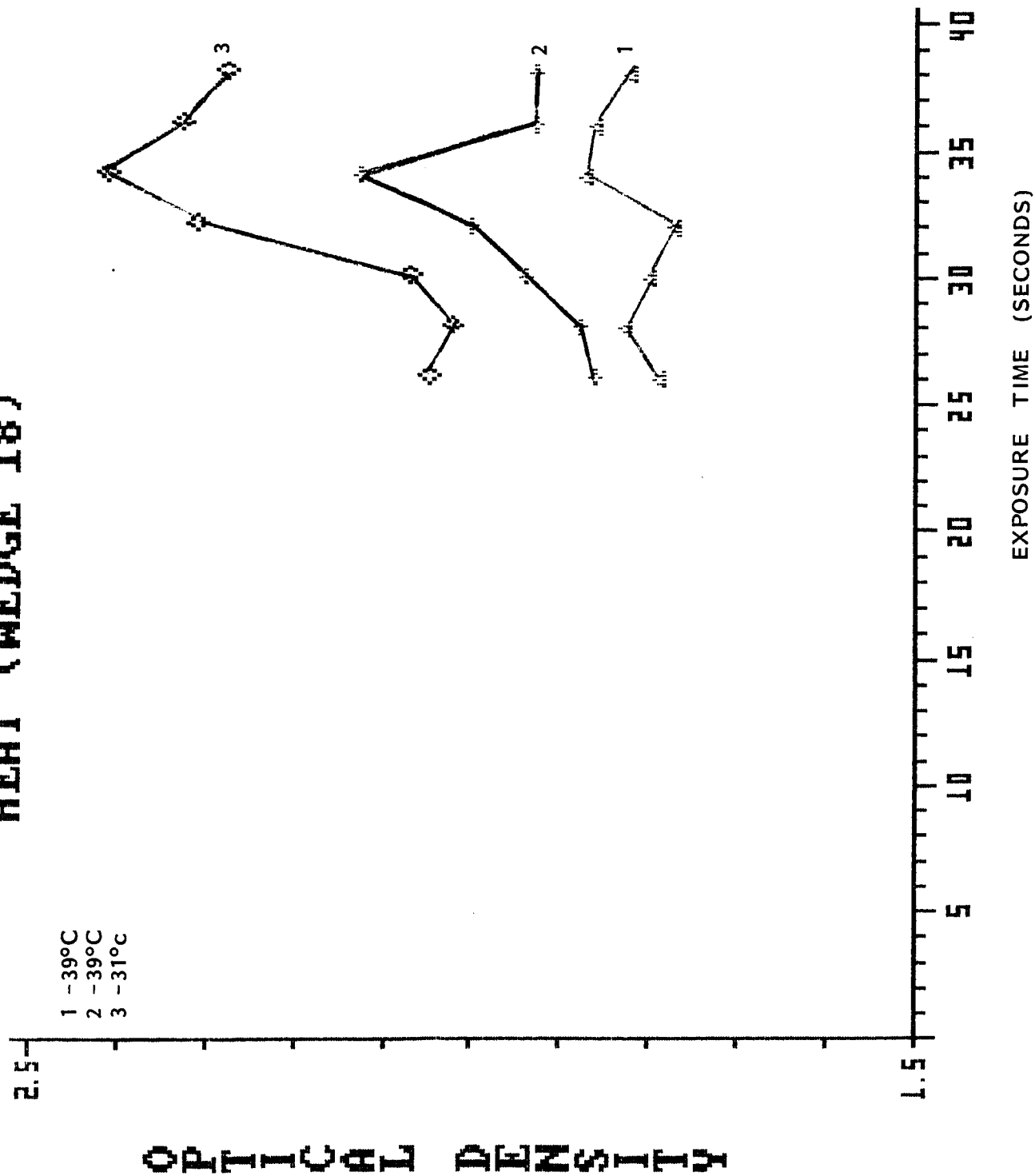
GRAPH #4



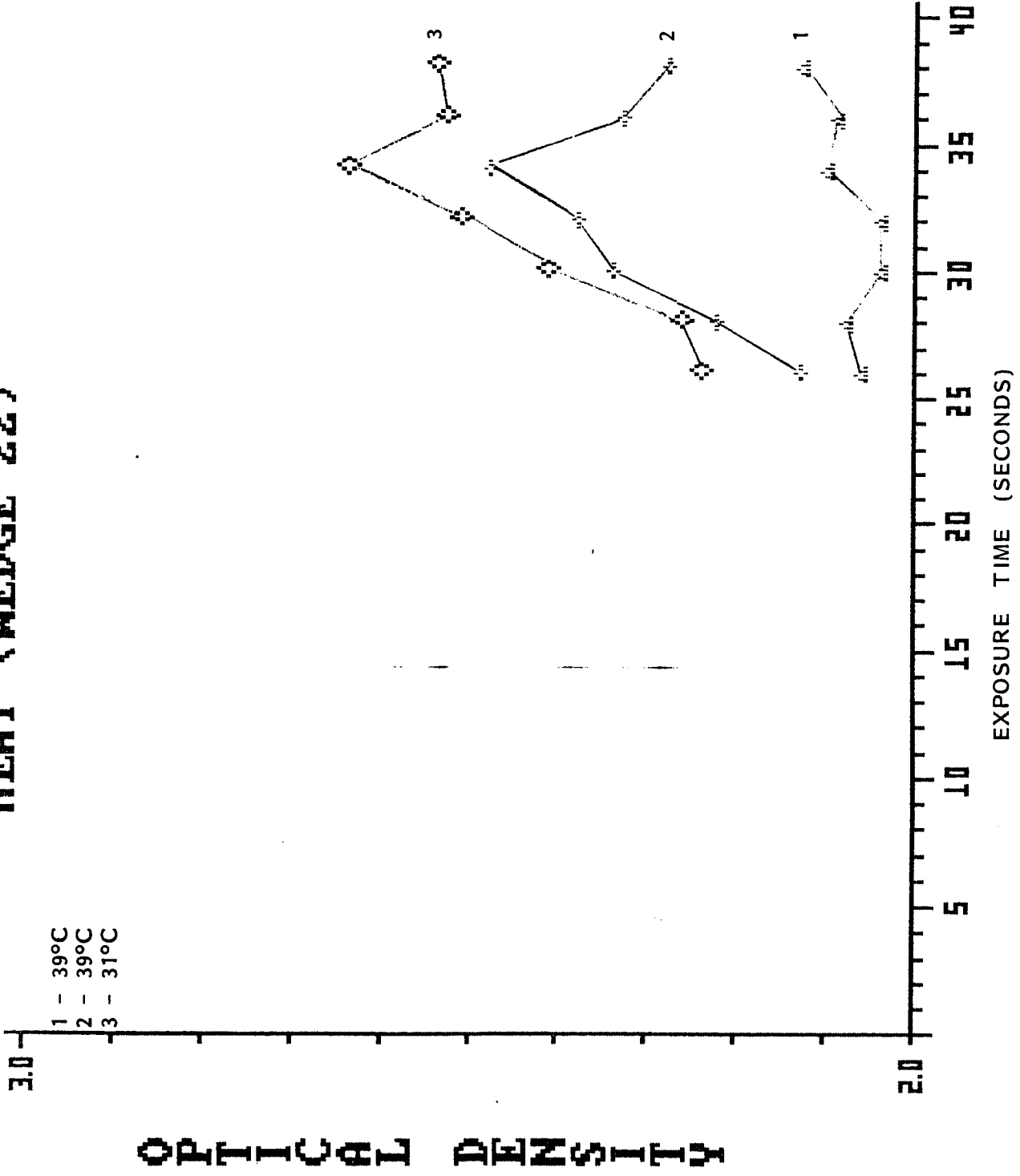
# HEAT (WEDGE 16)



# HEAT (WEDGE 18)

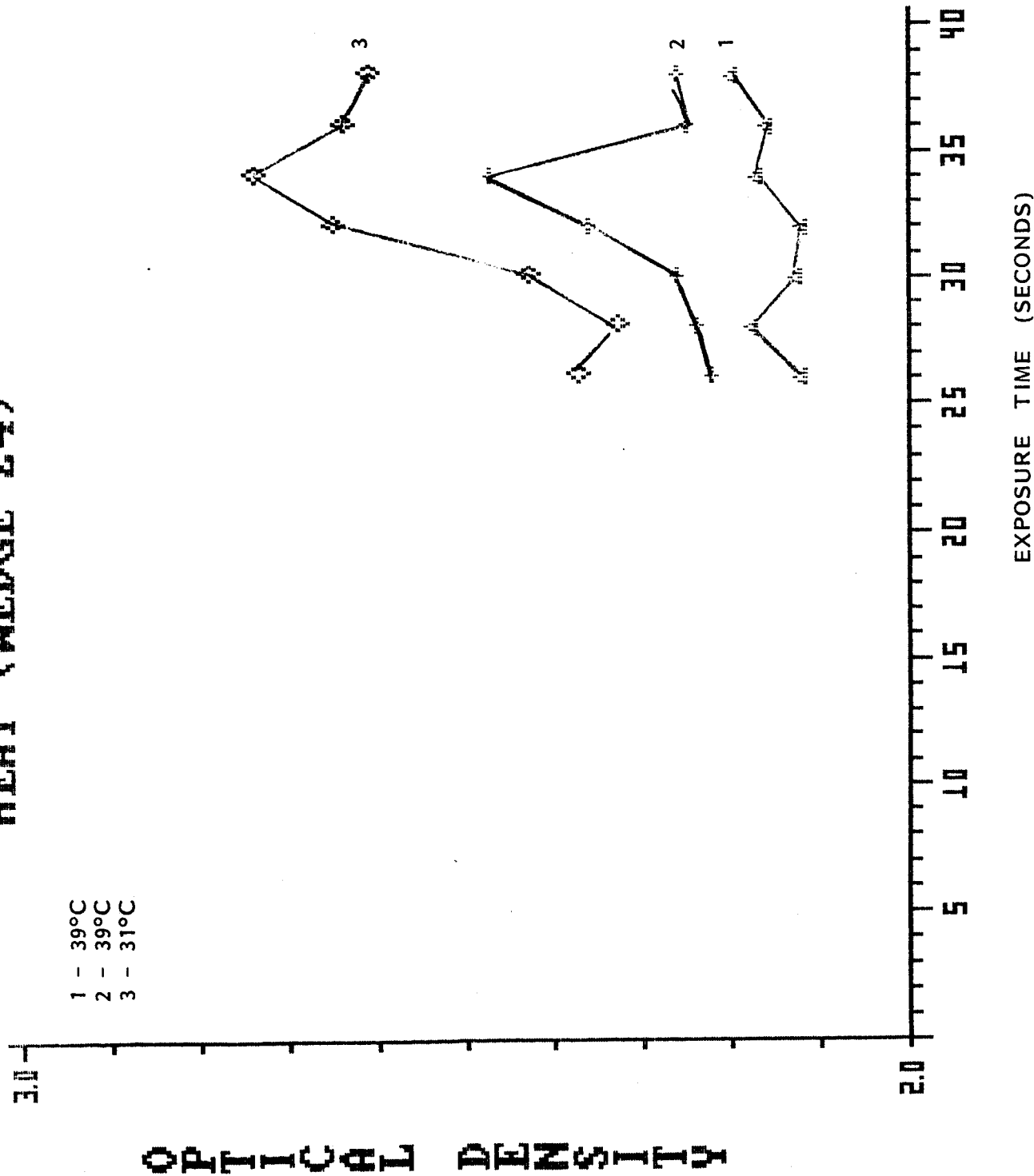


# HEAT (WEDGE 22)



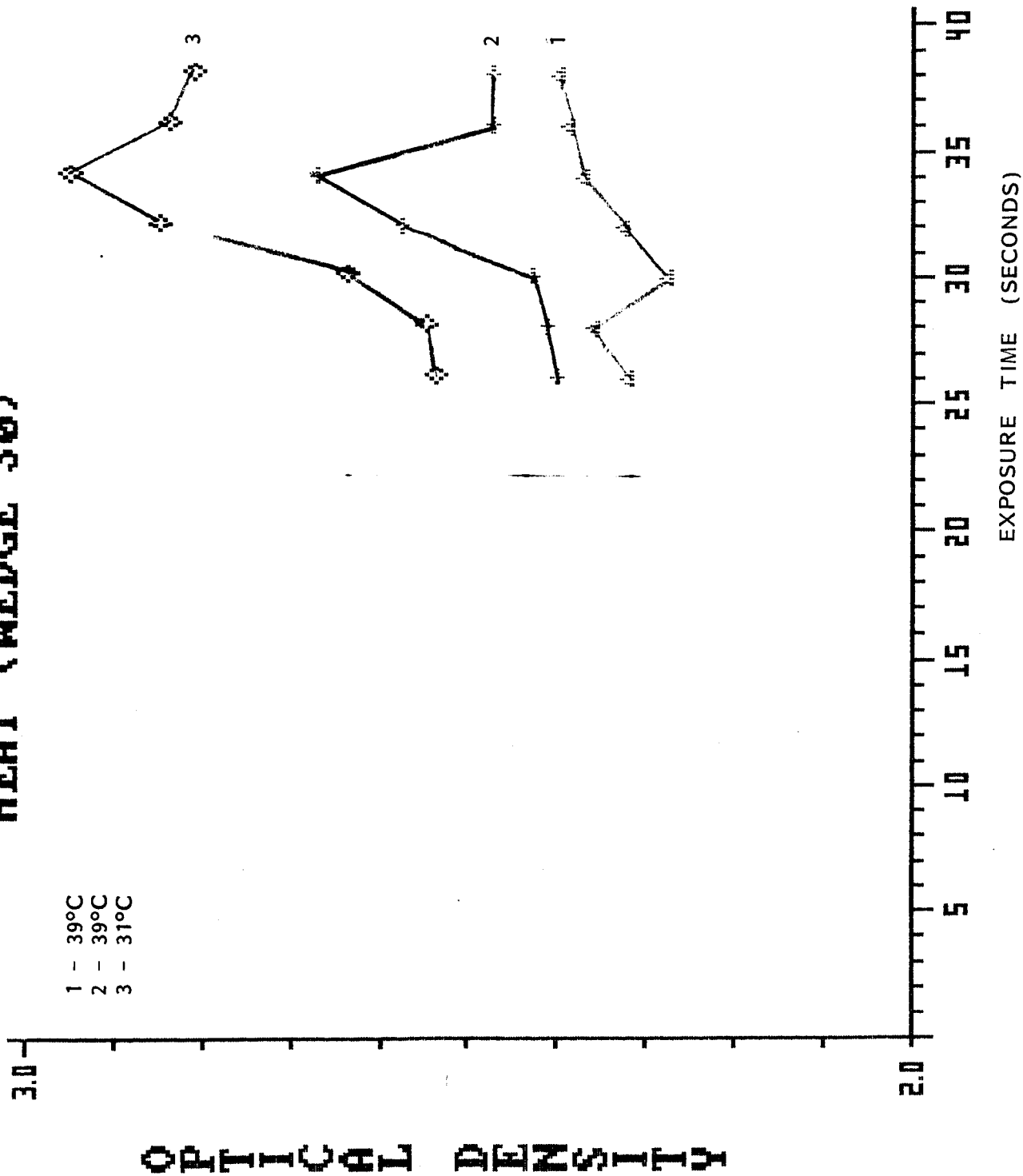
RECIPROCITY FAILURE

# HEAT (WEDGE 24)



# RECIPROCITY FAILURE

## HEAT (WEDGE 30)



GRAPH #9

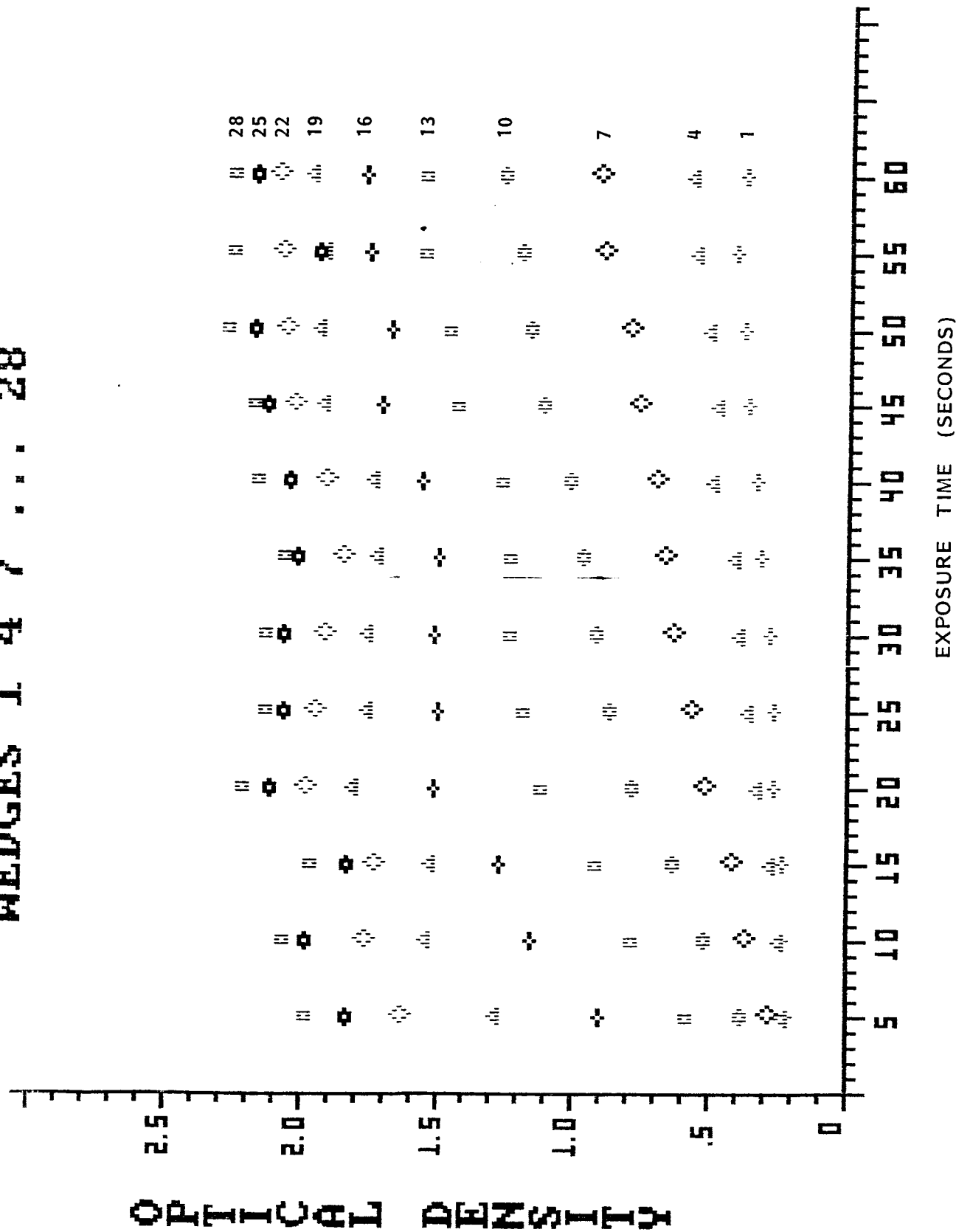
(C) Shifting of Reciprocity Failure Points as a Function of Thermal and Aging Effects

Two identical experiments were set up to detect reciprocity failure of 11a0 film between 5 and 60 seconds. This was done for verification of reciprocity failure of 11a0 film during these exposure times.

RESULTS

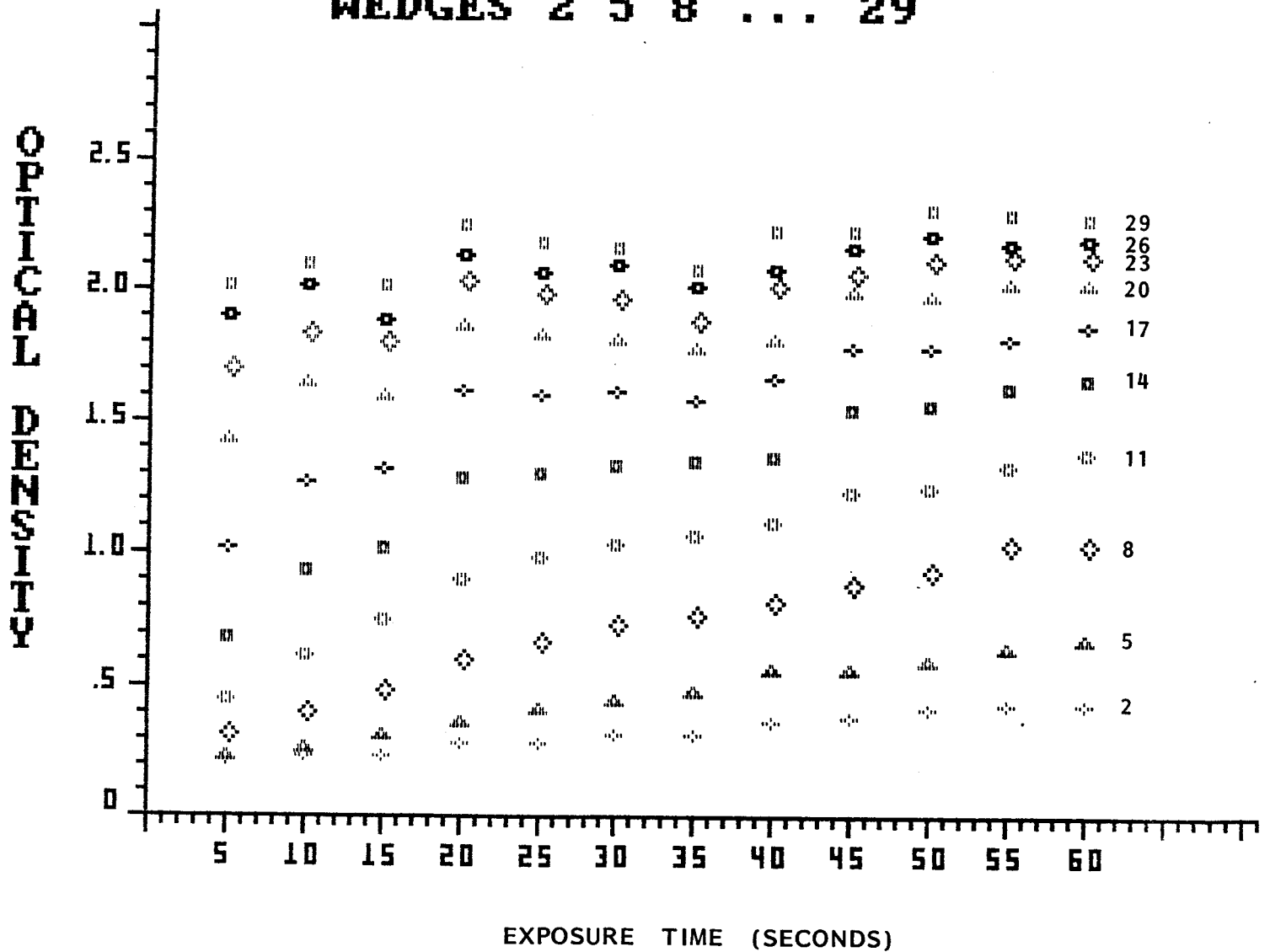
The data suggests that there is a shifting of the reciprocity failure points from film batch to batch. Set one, which was developed first, indicates that reciprocity failure is occurring at 15 and 35 seconds. (see graphs 1 - 3). Set two, which was developed last, indicates that reciprocity failure is occurring at 20, 35 and 40 seconds. (see graphs 4 - 6). Since this film was developed from the same batch there appears to be a shifting of the reciprocity failure points. This could also be due to thermal and aging of the film.

HEDGES 1 4 7 . . . 28



# RECIPROCITY FAILURE

WEDGES 2 5 8 ... 29

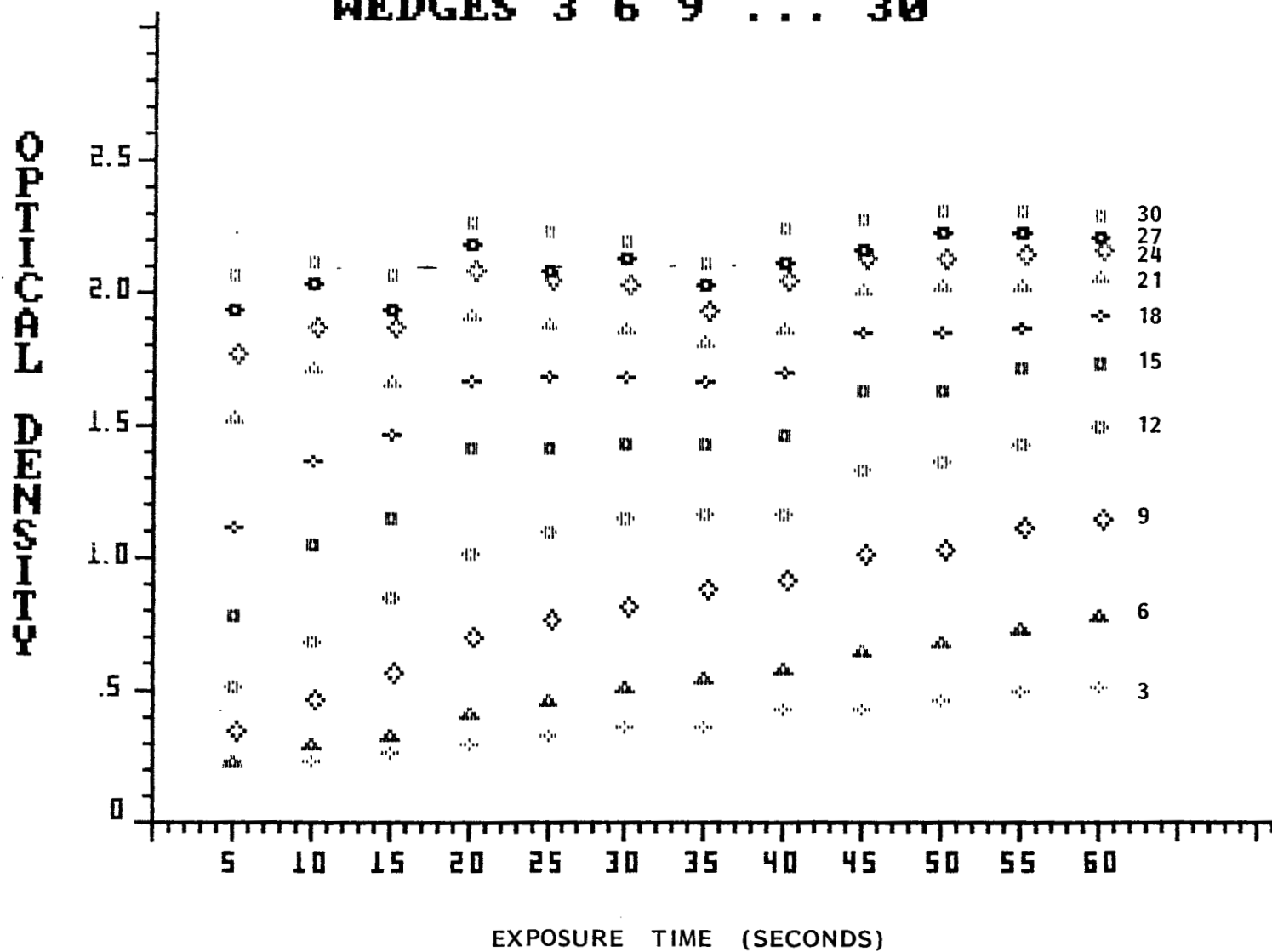


GRAPH #2



# RECIPROCITY FAILURE

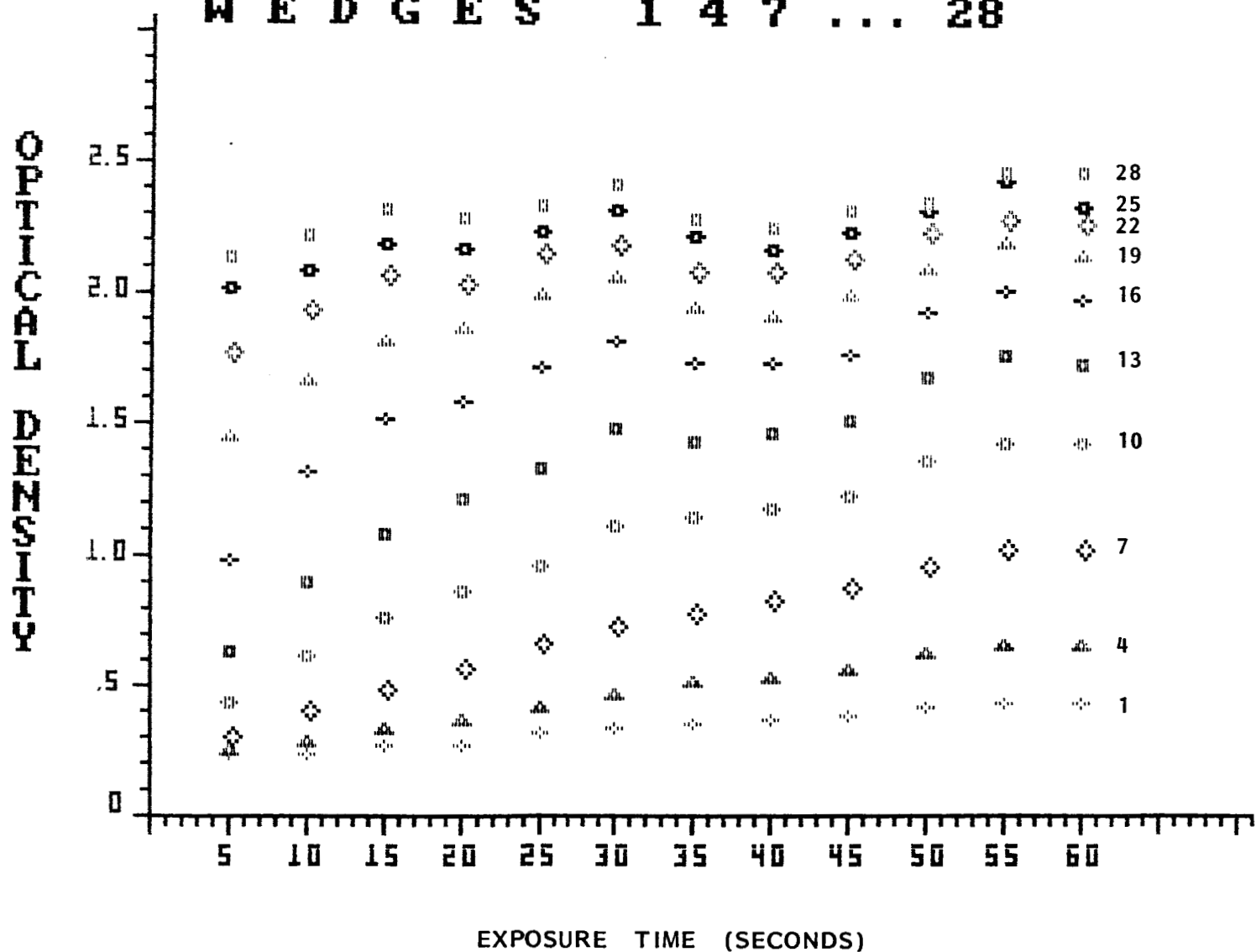
WEDGES 3 6 9 ... 30



GRAPH #3

# RECIPROCITY FAILURE

W E D G E S 1 4 7 . . . 28

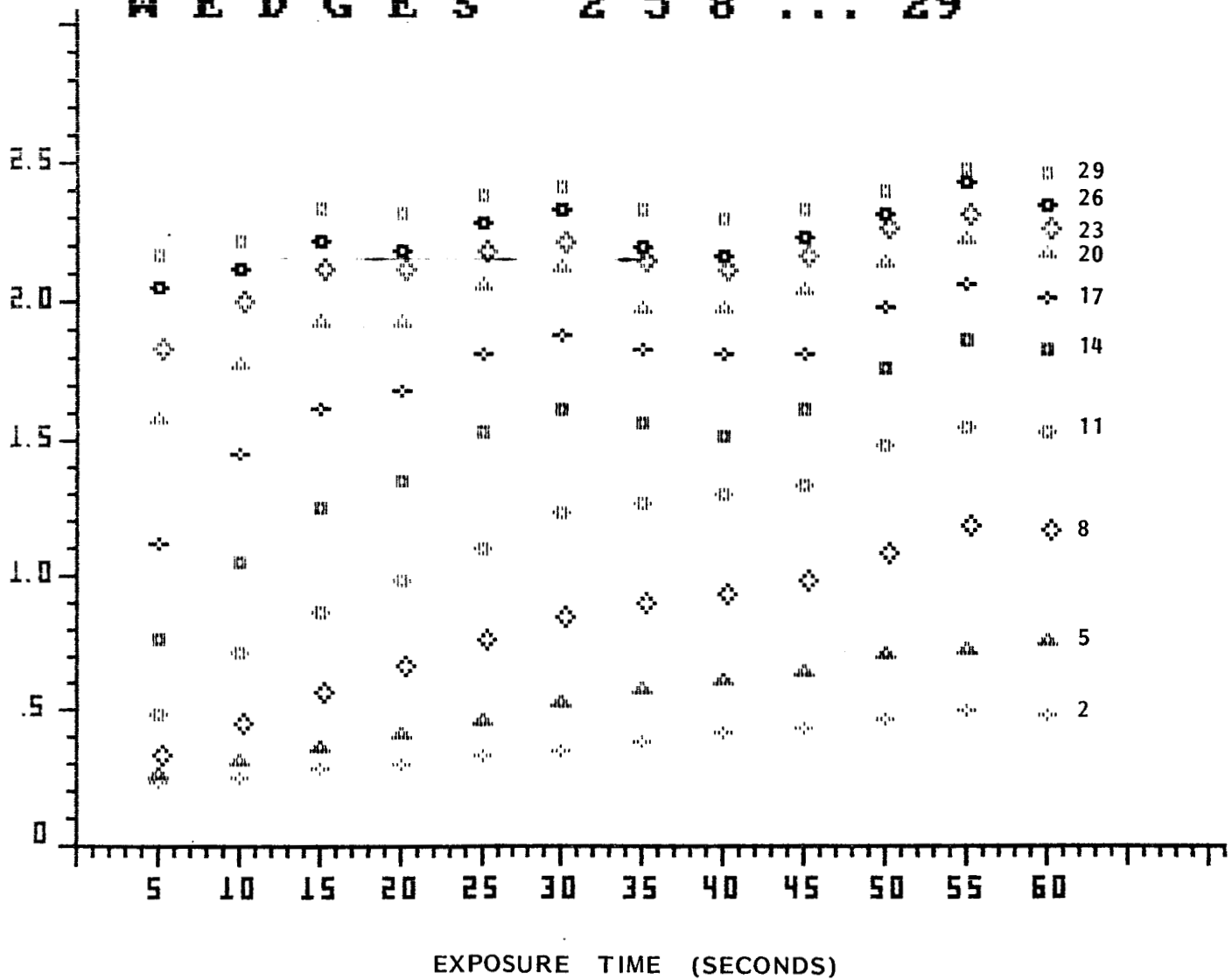


GRAPH #4

# RECIPROCITY FAILURE

W E D G E S 2 5 8 . . . 29

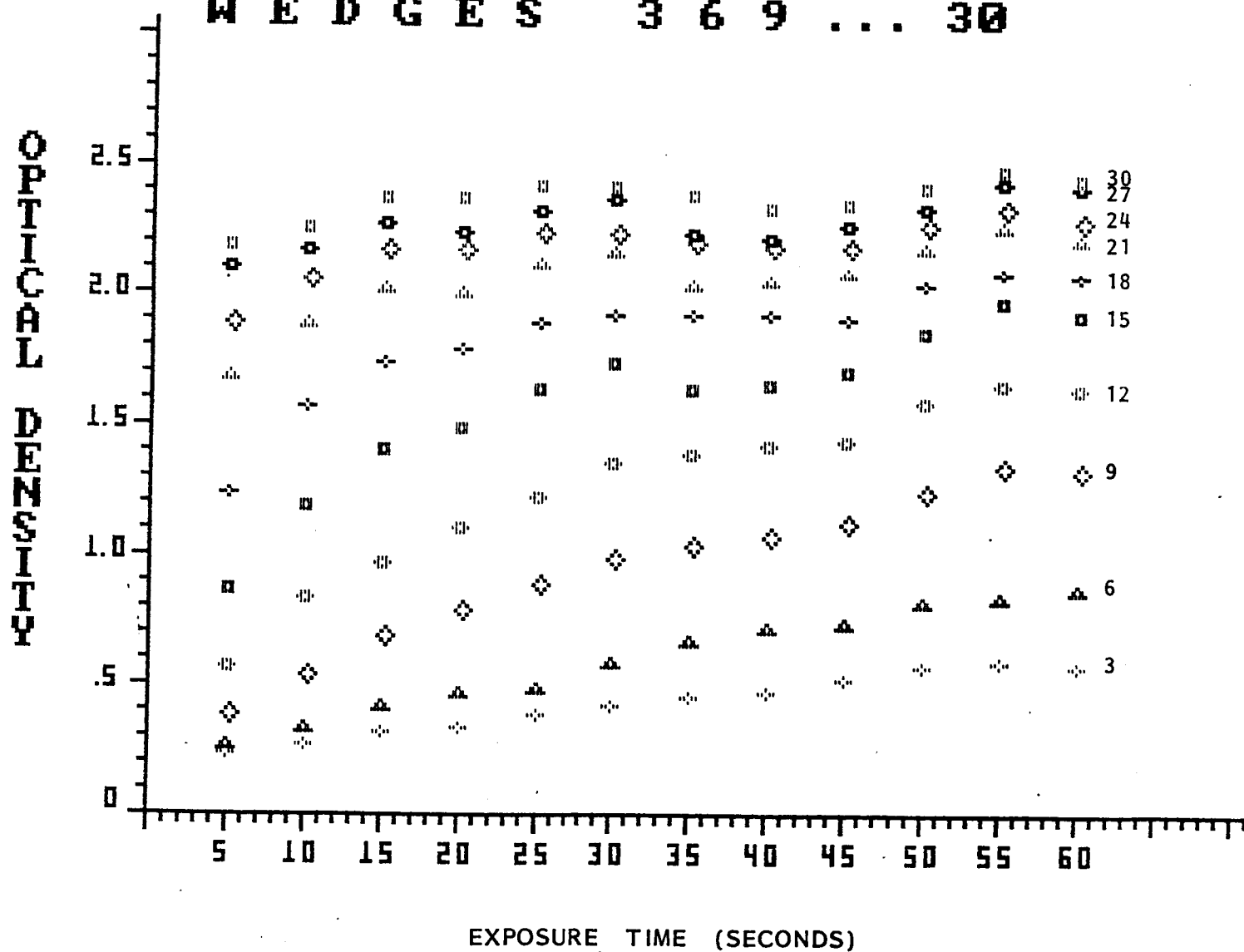
PHOTOGRAPHIC SENSITIVITY



GRAPH #5

# RECIPROCITY FAILURE

W E D G E S 3 6 9 . . . 30



GRAPH #6